6/

REPORT RESUMES

ED 003 176 56

THE DEVELOPMENT AND EVALUATION OF A CURRICULUM FOR EDUCABLE MENTAL RETARDATES UTILIZING SELF-INSTRUCTOR DEVICES OR TEACHING MACHINES.

BY- BLACKMAN, LEONARD S. AND OTHERS
EDWARD R. JOHNSTONE TRAINING AND RESEARCH CENTER
REPORT NUMBER NDEA-VIIA-368 PUB DATE 29 FEB 64
GRANT OEG-7-28-073
EDRS PRICE MF-$0.54 HC-$14.88 372P.

DESCRIPTORS- *AUTOINSTRUCTIONAL AIDS, *CURRICULUM DEVELOPMENT, *CURRICULUM EVALUATION, *EDUCABLE MENTALLY HANDICAPPED, PROGRAM EVALUATION, PROGRAMED INSTRUCTION, *TEACHING TECHNIQUES, INSTRUCTIONAL PROGRAMS, TEACHING MACHINES, BORDENTOWN, NEW JERSEY

AN EVALUATION OF SELF-INSTRUCTIONAL DEVICES IN THE CLASSROOM AND THE RELATED PSYCHOLOGICAL RESEARCH WERE PRESENTED. PART 1 COVERED PHASES OF MACHINE AND PROGRAM DEVELOPMENT, A REVIEW OF RELEVANT LITERATURE, AND THE MAJOR EXPERIMENT. EDUCABLE MENTALLY RETARDED 14-YEAR OLDS WERE SELECTED AND DIVIDED INTO TWO GROUPS. THE EXPERIMENTAL GROUP CONSISTED OF 19 PERSONS AND THE CONTROL GROUP, 17 PERSONS. BOTH GROUPS WERE PRE- AND POST-TESTED AT THE BEGINNING AND END OF THE YEAR. THE EXPERIMENTAL GROUP RECEIVED PROGRAMED INSTRUCTION AND THE CONTROL GROUP WAS TAUGHT CONVENTIONALLY. AN ANALYSIS OF THE DATA COLLECTED SHOWED NEGATIVE RESULTS IN THE EFFECTIVENESS OF MACHINE INSTRUCTION SKILL DEVELOPMENT WITH THE EXCEPTION OF ONE ARITHMETIC MEASURE. FURTHER RESEARCH WAS ENCOURAGED TO STUDY THE PSYCHOLOGICAL PROPERTIES OF SCHOOL TASKS. PART 2 INCLUDED THEORETICAL STATEMENTS AND LITERATURE SURVEYS. (RS)

ED003176

A-368
①

STATE OF NEW JERSEY

Department of Institutions and Agencies

Johnstone Training and Research Center
Bordentown, New Jersey

The Development and Evaluation of a Curriculum For Educable Mental Retardates Utilizing Self-Instructor Devices or Teaching Machines

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

February 29, 1964

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

The Development and Evaluation of a Curriculum for Educable Mental Retardates Utilizing Self-Instructor Devices or Teaching Machines

Title VII Project Number 368
National Defense Education Act of 1958
Grant Number 7-28-073.

Project Staff

Dr. Leonard S. Blackman, Principal Investigator
Dr. Rudolph J. Capobianco, Assistant Project Director
Mr. Michael J. East, Research Psychologist
Mr. David L. Hoats, Research Psychologist
Mrs. Dolores B. Glass, Administrative Assistant

Co-Principal Investigators:

Dr. Leonard S. Blackman
Teachers College, Columbia University

Dr. Marshall P. Smith
Trenton State College

This Project was conceived and conducted by the Research Department of the Edward R. Johnstone Training and Research Center in Bordentown, New Jersey

The Research Reported Herein Was Supported by a Grant from The U. S. Department of Health, Education, and Welfare Office of Education

February 29, 1964

The Development and Evaluation of a Curriculum for Educable Mentally Retardates Utilizing Self-Instructional Devices or Teaching Machines

Title VII Project Number 368
National Defense Education Act of 1958
Grant Number 7-28-073.

Project Staff

Dr. Leonard S. Blackman, Principal Investigator
Dr. Rudolph J. Capobianco, Assistant Project Director
Mr. Michael J. East, Research Psychologist
Mr. David L. Hoats, Research Psychologist
Mrs. Dolores B. Glass, Administrative Assistant

Co-Principal Investigators

Dr. Leonard S. Blackman
Teachers College, Columbia University

Dr. Marshall P. Smith
Trenton State College

This Project was conceived and conducted by the **Research Department of the Edward R. Johnstone Training and Research Center in Bordentown, New Jersey**

The Research Reported Herein Was Supported by a Grant from The U. S. Department of Health, Education and Welfare Office of Education

February 29, 1964

Acknowledgements

Many people contributed to this Project in addition to those whose names appear on and between the covers of this report. An important contribution, both in the conception and conduct of the study, was made by Dr. Belver C. Griffith, its first Assistant Director. Dr. Griffith, along with Drs. Philip Siegmann and Stanley Wechkin were instrumental in developing the specifications for the machine. Their careful research also formed the basis for some program development.

Research, literature surveys, testing, and invaluable professional consultation were generously provided by Drs. Herman Spitz, Ronald Lipman, George Saxton, Harris Kahn; Messrs. Edward Holden, jr. and Malvin Gelof; and Mrs. Ann Griffith.

The brunt of the programming effort in reading was borne by Dr. James Forcina, assisted by Miss Natalie Skrzydlinski and, in arithmetic, by Mrs. Margaret Jo Shepherd.

Since the major emphasis in this report is on the classroom evaluation of self-instructional devices, it should be clear that little could have been accomplished without the dedication, cooperation, and loyalty of the educational administrators involved: Maurice I. Tretakoff, Jay Rotberg, and Boris Bogatz. For their high frustration tolerance and experimental spirit, plaudits are richly deserved by Mrs. Lottie Barnes and Mr. Douglas Brown, the Project teachers.

The good right arm of the Project, in terms of its administrative, financial, clerical, and program-processing functions, was Mrs. Dolores B. Glass. She was ably assisted by Gail Cheesman, Christy East, Ora Flippen, Diane Gilliland, Hilda Schaefer, and Annette Weber.

Special thanks are extended to Dr. Joseph J. Parnicky, Superintendent of the Edward R. Johnstone Training and Research Center whose belief in the importance and value of research in the institutional setting is the rock upon which this and many other studies which have emanated from the Johnstone Center are built.

For the close cooperation of Trenton State College and its resources, appreciation is extended to Dr. Marshall F. Smith who, in addition to facilitating this liason, was responsible for the exhaustive glossary terminating the report.

TABLE OF CONTENTS

Part I The Classroom Evaluation

Page

Chapter 1 Introduction 2

Chapter 2 Selected Background Literature 8

Chapter 3 Technical Description of Teaching Machine 15

Chapter 4 Program Production and Library Unit 29

Chapter 5 The Reading Program 55

Chapter 6 The Arithmetic Program 83

Chapter 7 Procedure 141

Chapter 8 Results 146

Chapter 9 Discussion 162

Chapter 10 Summary and Conclusions 170

References 173

Part II Psychological Research Background

Chapter 11 Some Variables in Automated Teaching 179
Belver Griffith

Chapter 12 Support vs. Non-support in an Autoinstructional Word Program for Educable Retardates 190
Leonard S. Blackman and Edward Holden, jr.

Chapter 13 Achievement Measurement and Academic Grade Placement in Educable Mental Retardates 201
George Saxton, Leonard Blackman, and Maurice Tretakoff

Chapter 14 Effects of Different Learning Conditions on Short and Long Term Retention 205
George Saxton

Page

Chapter 15 Word Learning in an Automated Teaching Situation as a Function of Display Condition 214
Stanley Wechkin

Chapter 16 Word Discrimination as a Function of Difficulty Sequences 221
Stanley Wechkin

Chapter 17 The Application of an All-or-None Learning Model to Multiple-Choice Data on the Acquisition and Retention of Paired Associates 228
Ann Griffith

Chapter 18 Knowledge of Results and Tangible Reinforcement in Automated Instruction 273
Michael East, Rudolph Capobianco, David Hoats, and Malvin Gelof

Chapter 19 A Glossary of Terms Used in Auto-instructional Methods 282
Marshall Smith

Appendix A Alphabetic Listing of all Words in the Program 313

Appendix B The Reading Program 316

Appendix C The Arithmetic Program 356

Appendix D Behavior Rating Basal Scale 362

Appendix E Schematic Drawing of Teaching Machine 364

Part I

The Classroom Evaluation

Chapter 1

Introduction

Recent reviews of research in the development of self-instructional devices (see Chapter 2) have highlighted the dramatic progress being made in new concepts and instrumentation in educational psychology. The development of teaching machines have reflected the most direct and controlled application of learning theory principles to instructional techniques. The main characteristics of these machines and the programs that they display are:

1) active participation of students
2) immediate feedback
3) optimal sequential order of material
4) finely graded steps to insure mastery of old material before progressing to new.

In 1960, the Edward R. Johnstone Training and Research Center applied to the United States Office of Education for a research grant under the provisions of Title VII of the National Defense Education Act. The Project, entitled, "The Development and Evaluation of a Curriculum for Educable Mental Retardates Utilizing Self-Instructional Devices or Teaching Machines" intended to explore the value of these devices for a mentally retarded population. This appeared to be a logical research avenue in view of perennial attempts to establish maximally effective learning conditions for these children who exhibit such severe learning handicaps.

Considerations in several broad areas made the proposed Project seem particularly timely. Retardates, as a group, have special requirements that might be better met by self-instructional devices than by other classroom methods. First, retardates are known to make slow progress in a classroom situation, placing enormous time and temperament demands upon the teacher. An immediate feedback device is infinitely patient, extremely motivating, and can be programmed to move very slowly through new materials.

Second, for most educable mentally retarded children, there is a history, due to poor achievement, of receiving little or no reward in the school setting prior to their placement in special class programs. In addition, the usual rewards for good performance in school are likely to mean little to the educable child from a culturally and economically impoverished background. A self-instructional device, however, can be made to deliver a tangible reward, developmentally and culturally appropriate, whenever the subject makes a correct response. A further advantage is that the machine furnishes an impersonal environment that is not likely to arouse anxieties associated with past teacher-pupil relationships.

Third, the multiplicity of causes of mental retardation results, both in theory and practice, in a highly heterogenous group. Self-instructional devices make allowances for individual differences by permitting students to proceed at their own pace.

Fourth, by the very nature of intellectual deficit, a retardate's incidental learning from everyday experiences is frequently much poorer than the environment demands. For this reason, retardates must be trained more extensively and to a higher level of mastery. Self-instructional devices facilitate both aims. In particular, these devices make it possible to specify, in terms of over-learning, the degree of mastery achieved.

Fifth, the highly controlled teaching environment made possible by a teaching machine provided the opportunity to examine school materials carefully from the point of view of maximally efficient displays and the psychological skills related to their mastery.

The essential objectives of the study were:

a. to develop and program teaching machines for instructing mentally retarded children in primary language and arithmetic skills;

b. to carry out a series of studies that would attempt to resolve methodological questions about the most effective ways of constructing programs;

c. to compare the achievement of mentally retarded children using teaching machines and programs as a supplement to their regular instruction to equated groups being taught the same material by "traditional" special class techniques; and

d. to compare in- and out-of-school behavioral changes over the school year in the two groups.

The original strategy of this three year Project was to spend eighteen months in machine design and development, as well as basic methodological research designed to evoke both a theoretical and empirical foundation for principles of sound program-writing, six months in constructing the equivalent of approximately two grades of reading and arithmetic programs, and, finally, the one year classroom evaluation of the effectiveness of machines and programs, with a mentally retarded population.

Reviewing the many obstacles and setbacks in the design and construction of the machines as well as our naive estimate of the amount of time required for writing and processing large quantities of program materials, it seems, in retrospect, almost impossible that the Project did progress through and complete all phases of its program. The most difficult period of the Project came between the end of the 18 months of machine development and methodological research and the beginning of the application of these findings to the task of program development and classroom evaluation. It was at this point that many of the psychologists on the Project staff felt that the research which had been completed did not provide sufficient definitive evidence that would specifically recommend one approach to writing programs over another. Some of the studies which compared different program techniques found little difference between them. Other findings, although pointing to the efficacy of a particular technique, were at variance with the results of similar research done elsewhere. In spite of the fact that the background research efforts offered little concrete guidance to the program writers, the decision was made to go ahead with construction of programs with whatever little information was available and with the help of methods specialists in the areas of reading and arithmetic.

The result has been a library of reading and arithmetic programs which, if not the most scientifically well grounded, was creatively conceived and represents the most extensive library available anywhere. Apart from the data specific to the objectives of the Project, the classroom evaluation phase also provided: (1) an understanding of the serious logistical problems involved in the preparation, storage, and distribution of the program film and tapes required in the machine; and (2) the resolution of management problems relating to the utilization and integration of teaching machines into the classroom routine.

The chronology of research events, as described above, has been reorganized for the purposes of this report. The report is divided into two parts. Part I covers, in a comprehensive fashion, all phases of machine and program development and the major experiment, the comparison of teaching machine and "traditional" instruction in accelerating the achievement of educable mental retardates. Specifically, Part I includes a selected review of relevant literature made by Dr. George H. Saxton of Trenton State College, a technical description of the Teaching Machine and the stages in its development written by Mr. David Hoats, a description of the process by which program materials were prepared written by Mr. Michael East, a detailed description of the reading program developed by Dr. James Forcina of Trenton State College, a similar analysis of the arithmetic program by Mrs. Margaret Jo Shepherd, and the report of the experiment itself.

Part II includes research, theoretical statements, and literature surveys completed during the first 18 months of the Project.

Studies comparing display conditions, reinforcement contingencies, prompting techniques, testing procedures and highly theoretical analyses of multiple-choice data constitute the bulk of this section. In addition, a complete and up-to-date glossary of terms used in auto-instructional research has been provided.

It is the intent of this report to carry the reader through a highly detailed description of this research venture in all its stages and phases. The purpose of such a highly analytical report is twofold. First, it will facilitate the replication of any part or all of this massive undertaking either for research or program development. Second, it will elucidate the process of doing pioneering research in a poorly defined area where "hardware" and techniques had to be constructed "from the ground up." To the staff of this Project, the process was at least as enlightening as the product.

Finally, it will be noted that this report is the result of the efforts of many people. Few who began with the Project remained with it until its conclusion. Psychologists and educators worked together at various stages of the program with psychologists carrying the major responsibility for machine development and background methodological research while educators bore the brunt of programming and supervision of the classroom evaluation. It is not typical for psychologists and educators to work cooperatively on problems relating to the teaching-learning process in the school context. Perhaps the special characteristics of programmed instruction and the special needs of the mentally retarded create an unusually favorable climate for this long needed liaison. Hopefully, it is a harbinger of further joint efforts in other aspects of the educational process.

Chapter 2

Selected Background Literature

The enthusiasm for programmed instruction with mentally retarded students, as indicated by the increasing quantity (not always accompanied by equally impressive quality) of literature published within the last few years, can be attributed to several basic factors. 1) The opportunity of significantly increasing knowledge of the basic learning processes in retardates, as well as normals, via the "teaching machine bridge" between controlled laboratory experimentation and classroom research. 2) The possibility that retardates can learn more academic skills than previously realized with conventional teaching methods. Indeed, Stolurow states, "... there are studies showing that with efficient programming of learning materials the correlation between a measure of intellectual ability or of aptitude, and learning scores tends to be reduced to zero. Thus, it would appear that with efficient methods of learning the poorer student is assisted sufficiently so that he becomes, in terms of criterion performance, indistinguisable from the more able students" (Stolurow, 1960, p. 438). 3) The excessive demands placed on the small number of teachers trained to work with mentally retarded students, in and out of institutions, may be compensated for, to some extent, by self-instructional devices that could free teachers from many repetitive drill-type tasks to work more intensively with individual students on materials which do not lend themselves readily to this type of presentation.

The present literature review, as implied in the title of this chapter, is selective rather than exhaustive. The first section attempts to offer some perspective regarding other teaching machine studies and grants in progress during the period of the Johnstone Project which have attempted, broadly, to compare the effectiveness of teaching by programmed instruction with conventional methods. The second section discusses in greater detail, the findings and implications of some specific studies. As an aside, a special plea is made for increased publication of studies in this area in standard sources and journals. Considerable frustration and failure to obtain papers was encountered due to limited availability of some mimeographed source material.

I. Stolurow (1963) summarized, in table form, fourteen large scale investigations of programmed instruction with mentally retarded students (see Table 2.1). Language (reading, spelling, language arts) and arithmetic are currently the most popular areas of study. Stolurow points out that this is not surprising in the language area due to the frequent difficulties experienced by educable mentally retarded children. Arithmetic programming may enjoy a certain popularity since there have been proportionally more studies with positive results in this area than in others (Calvin, 1961; Keislar, 1959; Smith & Quakenbush, 1960).

TABLE 2.1

Studies of programmed instruction with mentally retarded students[a]

Principal Investigator	Institution	Supporting Agency	Topic	Status
D. Ellson	Indiana U	USPHS	R	C
M. Woolman	Inst of Educ Res	NIH	R	I
L. Malpass	U So Florida	USOE Coop Res	RS	I
J. Price	Partlow Sch Ala	USOE Title VII	A	C
J. Kleiser	Devereaux Fdn	NIH	A	I
F. Payne	Macfarland Jr. Hi Washington, D. C.		RSA	C
J. Birnbrauer	U of Wash, Seattle		TP	I
L. Stolurow	U of Ill	USOE Coop Res	LA	I
L. Blackman & M. Smith	Johnstone Tr. Cntr	USOE Title VII	RI	I
G. Cartwright	U of Ill	USOE-U of Ill	A	C
D. Merachnik	Berkeley Hts, NJ		A	I
C. Shay	U of Cal L. A.		I&S	C
Naumann & Woods	Cen Wash St Coll		S	C
J. Holland	Fernald St Sch		IR	C

Key

Topics: R-Reading, S-Spelling, A-Arithmetic, TP-Total Program, LA-Language Arts, I&S-Intelligence and Step Size, IR-Inductive Reasoning.

Status: C-completed, I-in progress.

Notes

[a] A summary of the proposed work on many of these projects is available from the Science Information Exchange Smithsonian Institute, Washington 25, D. C.

Referring briefly to Table 2.1, several investigators have reported varying degrees of success with language and reading programs; e.g., Ellson, Malpass, Stolurow, and Blackman and Smith. There seems to be no question that retardates can learn to read and spell through programmed instruction. There is question, however, regarding the extent of its superiority over more traditional methods of instruction. It is possible that a question of this magnitude is unanswerable with current experimental and statistical techniques. Of course, the literature on normals and retardates contains its share of teaching machine and various types of "control" group comparisons. Positive results have been obtained by Porter (1959), Komoski (1960), Osler (1960), Raygar & Wark (1962). Several studies included non-instructed controls for incidental learning with positive findings (Belcastro, 1961; Keislar, 1959; McNeil, 1962. Negative results, comparing programmed with some type of more traditional instruction were found by Bugby & Mann (1962), Sprague & Binder (1962) & Hough (1962). Generally negative results have been reported in teaching machine-programmed textbook comparisons (Gotkin & Goldstein, 1962; Eigen et. al. 1962; Eigen & Komoski, 1960).

Meyer (1959) encountered problems with a sizeable minority of second grade children using a teaching machine for arithmetic instruction. Hively's (1960) exploratory work with visual discrimination in pre-school children was encouraging to those who would apply programmed instruction techniques at this level. The implications of studies yielding non-significant achievement differences between programmed instruction and control groups are qualified by the fact that instruction time is significantly less in the programmed group (Hough, 1962).

The implications of these findings are difficult to assess unless the nature of the control group is clearly understood. If "control" implies an unsystematic and possibly poorly organized presentation of material, whether by standard textbook or teacher, then the superiority of programmed instruction techniques can be attributed to any number of variables. In many studies, a more parsimonious explanation of the findings might be that a sloppy presentation of materials to be learned was less efficient than a well organized presentation rather than an elucidation of the virtues of automated teaching devices per se. This is not to say that programmed instruction has no specific advantages over well presented traditional methods but that many of the principles of programmed instruction have not been tested under adequate control conditions to warrant some of the generalizations advanced.

Recommended general source material and reviews are: Stolurow (1961, 1963); Silberman (1962); Galanter (1959); Warburton (1962); Porter (1957); and Lumsdaine and Glaser (1960).

II. To elucidate some issues more clearly, it is appropriate to focus on some specific studies representative of current research methodology employing programmed instruction in the teaching of arithmetic and language arts.

Smith and Quackenbush (1960) used a teaching machine as supplemental instruction in arithmetic. Ss were adolescent slow learners. The device was of the multiple-choice type with three alternatives for each problem. A buzzer provided the reinforcement when an appropriate button was depressed. Problems were presented in booklet form, the booklet resting on the teaching machine between two rows of buttons. A control group was obtained by studying comparable Ss' performance in arithmetic from the previous year, with no supplemental teaching machine instruction. The dependent variable was measured by increases in grade level scores on the California Achievement Test. A significant difference at the .05 level, using a one-tailed test, was obtained favoring the teaching machine group. Reading and language were also studied, but teaching machines were not employed in these areas.

Hosmer and Nolan (1960) compared normal classroom instruction (control group) with normal instruction plus a programmed scrambled book, using multiple-choice responses (experimental group). It is of interest that slow paced learners learned as much as fast paced learners in the experimental group. Teaching machine instruction also covered material in approximately half the time required for regular instruction.

Support for rapid as well as effective learning for "slow learners" might be found in Shay's (1961) study of the relationship of intelligence to step size. Shay studied the performance of three IQ groups; i.e., IQs over 110, IQs between 93 and 109, and IQs under 92, on programs written for a fourth grade unit in Roman numerals. His results and subsequent conclusions were that if there is a relationship at all between intelligence and step size, it is very weak and alternate programs are not indicated on the basis of ability alone. It would appear, therefore, that many high grade retarded students could perform adequately on programs developed for normal learners. In a similar vein, Smith and Moore (1961), working with 95 fifth graders of normal intelligence, found no differences in spelling achievement between six groups of children working through programs which differed in step size.

Calvin (1960, 1961), using eighth grade students of average mathematical ability, obtained quite impressive results in learning and retention for a ninth grade mathematics course. The students were instructed by machine only, and, "were able to cover an entire year of ninth-grade algebra in approximately one semester." The students were questioned at the end of the experiment and only 16% preferred to return to traditional classroom methods. Furthermore, approximately one year after the onset of the teaching machine instruction, students were retaining an average of 90% of what had been learned. The authors discuss the lack of adequate control groups for this particular experiment, and the consequent need for reservation in extrapolating the data to other instructions.

Understanding in arithmetic, as well as facts, has been successfully taught with teaching machines (Keislar, 1959). Although normal elementary school students were used as Ss, there is no reason to assume that many equal MA retardates would not be able to profit from the instruction. Keislar's experiment involved instruction in understanding areas of triangles. A group of matched controls received no instruction of any kind to control for incidental learning after the initial pretest. The experimental (teaching machine) group showed significant development in understanding.

Sprague & Binder (1962) compared conventional classroom instruction with teaching machine instruction in arithmetic, using fifteen mental retardates as Ss. The dependent variable was measured by: (1) California Achievement Test; (2) an Arithmetic Test; and (3) programmed problems. The retardates learned by the machine, and maintained high cooperativeness and attentiveness. There were no significant differences, however, between the two modes of instruction.

Complete programmed instruction in reading presents more challenge than arithmetic. Ellson (1961) aptly summarizes the problem in teaching oral reading by stating "machines do not listen well- they cannot distinguish (and thus differentially reinforce) correct and incorrect oral responses with the proficiency required for teaching purposes". Blackman & Smith, using an elaborate electronic teaching device with synchronized auditory and visual stimuli, had success in teaching word recognition although even this complex machine and program did not "listen" or develop the learner's oral response. Ellson is working with an interesting technique in which retardates are trained as tutors to supplement the machine. Stolurow (1963) points out the potential value of this approach to institutions.

Malpass & others (1960, 1962a, 1962b) have been comparing two different teaching machine procedures using reading programs. These include a multiple-choice device designed by Holland and a typewriter keyboard device developed by Moore and Wyckoff. Preliminary results described in a progress report indicate that both experimental groups have doubled their sight recognition vocabulary. The period of teaching machine instruction lasted two months with

students using the devices 20 minutes per day, five days per week. Both groups were exposed to 6000 frames covering 72 words. Although data were not available for the multiple-choice device, the keyboard group showed 90% retention after 30 days.

Stolurow & Lippert (1962) discussed two studies dealing with prompting and confirmation sequences in programming a sight vocabulary for educable mentally retarded students. The prompting sequence involved, first, the presentation of the word to be learned (cue-stimulus); second, the presentation of the prompt (eliciting stimulus) or something that makes the desired response highly probable e. g., a pictorial representation of the word to be learned; third, the learner makes an overt response, e. g., says the word. The confirmation sequence involves, first, the presentation of the cue-stimulus; second, the learner makes the overt response; and third, the eliciting stimulus is presented. The results of the first study showed that the prompting sequence was not efficient for learning; but, that the confirmation sequence with a high level of overlearning produced superior retention after seven and 30 days. Stolurow discussed the implications of these findings in terms of S-R contiguity. The second study, designed to evaluate different proportions and combinations of prompting and confirmation sequences, found no significant differences in learning. In the retention data, however, higher scores appeared to be associated with more prompting than confirmation trials up to a total of 12 trials.

Blackman and Holden (1963) compared a support (prompting) program with a non-support (confirmation) program for teaching four words to equated groups of educable, non-reading adolescent retardates. Three measures of the dependent variable were used: (a) number of responses to complete successfully 16 randomized test frames terminating the program; (b) the number of words read from cards immediately after the program; and (c) the number of words read after 24 hours. A multiple-choice type teaching machine (described elsewhere in this paper) with audio and visual components was used. There were no significant differences between support and non-support programs; however, the students learned under both programs. These results were confirmed by Hawker, Geertz, and Shrago (1963) who also found significant learning but no differences between confirmation and prompting procedures using mentally retarded Ss whose average IQ was approximately 40.

Blackman and Holden make the point that the prompting program involved about twice the time as the confirmation program, and yet was not significantly better. The importance of the amount learned per program time was stressed. Considering Stolurow's

initial findings of better retention with confirmation procedures combined with overlearning, it would seem that this type program may have more potential than many programmers now appreciate.

Wechkin (1962) found that in reading instruction, visual response alternatives with auditory stimuli gave significantly better learning and better retention than auditory response alternatives with visual stimuli. Ss were delinquent adolescent girls having normal intelligence and a minimum of fourth grade reading skills.

Teaching machine potentialities for reading instruction with mental retardates are not to be minimized in any way because of the difficulties in programming and hardware. The failures that many retardates have experienced in reading may well have been a function of an unfortunate gap between what reading instruction should be, according to the experts, and the type of instruction to which they were actually subjected.

The need for highly expert reading teachers, working in ideal environments, is exemplified in the following studies oriented toward normal populations. Probably, mentally retarded students need expert instruction even more than normals. It is suggested here, that programmed instruction techniques may fulfill many of the following requirements for desirable reading instruction.

Betts (1958) stresses the importance of effective class organization, high levels of professional teaching competence, careful consideration of reading levels and individual interests, and goals of instruction. Glock (1958) points out that understanding and transfer of learning need not accompany teaching by telling, guiding, or imitation if students cannot see reasons for this type of learning, or have specific practice in applying the learning. Hart (1959) compared the performance of students taught in homogeneous ability groups with students taught in regular classroom groups and found the homogeneously grouped students to do significantly better. There is evidence, too, that with refined testing, there are no significant differences in variability in reading, arithmetic, and language achievement between different IQ levels (Klausmeier, Lehmann, and Beehan, 1959), adding more support to the argument that retardates cannot be thought of as a highly homogeneous group.

Morgan and Stucker's research (1960) with the Joplin plan of reading instruction is of interest to students of programmed teaching. Ss were 90 matched pairs of fifth and sixth graders.

Ss and teachers were randomly assigned to experimental and control groups. The experimental Ss were taught in groups of their own reading level, control group Ss by more standardized classroom techniques. The experiment ran for one year. Results significantly favored the experimental group. The authors concluded that significant factors favoring the group were: the experimental teacher could offer more verbal and emotional rewards; and students were in a non-threatening atmosphere, maximizing positive feedback from material "he can now read". There are certainly some similarities between the advantages mentioned above and teaching machine approaches to reading instruction.

A trite way of summarizing most of the "shoulds" in reading instruction might be that we need superior teachers with sufficient time to consider individual abilities for reading. One criterion of a superior teacher might be a familiarity with the research literature. Clymer (1958), however, comments on the problems of teachers applying reading research findings to the classroom. These include the teachers' lack of knowledge of research findings, their lack of knowledge of how to apply the research findings, the lack of community and administrative support for making changes, and the lack of proper teaching conditions to encourage teachers to best efforts. Suggested reading research reviews are: Clymer (1958), Traxler (1959), and Gray (1959).

The last, and possibly most important aspect of programmed instruction to be treated here is the impact of the impersonal machine on the highly personal teacher-student relationships. There is certainly no question that the teacher's personal influence is one of the most important variables determining a student's motivation. Warburton (1962), reviewing educational psychology for the Annual Review of Psychology writes,

> "One gains the impression from a perusal of the literature on teaching methods that differences in technique and organization tend to be swamped by teacher differences" (p. 386).

Ryans (1960), reporting on a very comprehensive study of teachers, has found evidence that children are significantly affected by two major personality variables in the teacher, extraversion-introversion, and anxiety-stability.

The student's need for individual attention from the teacher can be satisfied at times without face-to-face contact. Page (1958) conducted an experiment to assess some aspects of teacher comments on student performance. Teachers gave an objective examination, then randomly assigned students to one or three groups. In one group, the teacher made free written comments on the student's performance, in another the teacher wrote one of five set comments, and in the third group the teacher wrote no comments. The dependent variable was measured by scores on another objective examination after the students had received the comments. The results were that free written comments were superior to the five set comments which were superior to no comment. It is also of interest in the present paper that poor students were just as responsive to written teacher comments as better students.

The possibility of combining written teacher comments on programmed instruction materials, which would be immediately returned to the students, seems to offer an excellent opportunity to reduce some of the mechanistic and impersonal aspects of this kind of instruction, without eliminating the same impersonal aspects of the machine which are occasionally desirable for their limitless patience and frustration tolerance.

From the experience of this Project and others, programmed instruction techniques would appear to lend themselves to highly efficient handling of drill-type materials which often lead to negative teacher-pupil interaction, and to freeing the teacher for the more creative and rewarding types of instruction which can maximize the more positive aspects of interpersonal contact.

Chapter 3

Technical Description of Teaching Machine

David L. Hoats

The Johnstone-Bionics Mark II teaching machine may be described at several levels. This report will consider the machine on two levels: 1) as a simple electronically coupled audio-visual device; and 2) as a rather more complex electronic-optical device. To assist the non-technical reader over the electronic hurdles, some of the systems will be greatly simplified.

The Teaching Machine as an Audio-Visual Device.

The Johnstone-Bionics Mark II teaching machine (Fig. 3.1) is one of the pioneer efforts to build a machine which would allow for coupled audio and visual programs. It is, considered simply, a 35mm, single frame projector and screen contained in a steel cabinet with a tape recorder. The student listens with headphones to the tape recording which describes the visual display he sees on the screen. At the end of the description, the tape tells the student to make a response by pressing one of four buttons along side the screen, in proximity to the projected choices. Each presentation is known as a frame, with audio and visual components. If the student presses the correct button, a green light above the screen informs him that he is correct and the program advances to the next frame. If the student makes an incorrect response, a red light above the screen informs him that he is wrong and should try another response. Ordinarily, the program does not advance when the student makes an incorrect response.

The sequence of events, as described above, is automatic. It is necessary, when the machine is operating perfectly, only to instruct the student on his part of machine operation (e.g., which buttons he is to push, what the red and green lights mean), load the projector and tape machine, place headphones on the student and press the "tape start" button on the control panel. Of course, focus of the projector and sound volume should be checked and adjusted if necessary.

The Teaching Machine qua Machine

The following discussion will consider some of the more technical aspects of the machine. For purposes of clarity, the machine may be broken down into three interlocking systems: 1) Optical; 2) Mechanical; and 3) Electronic.

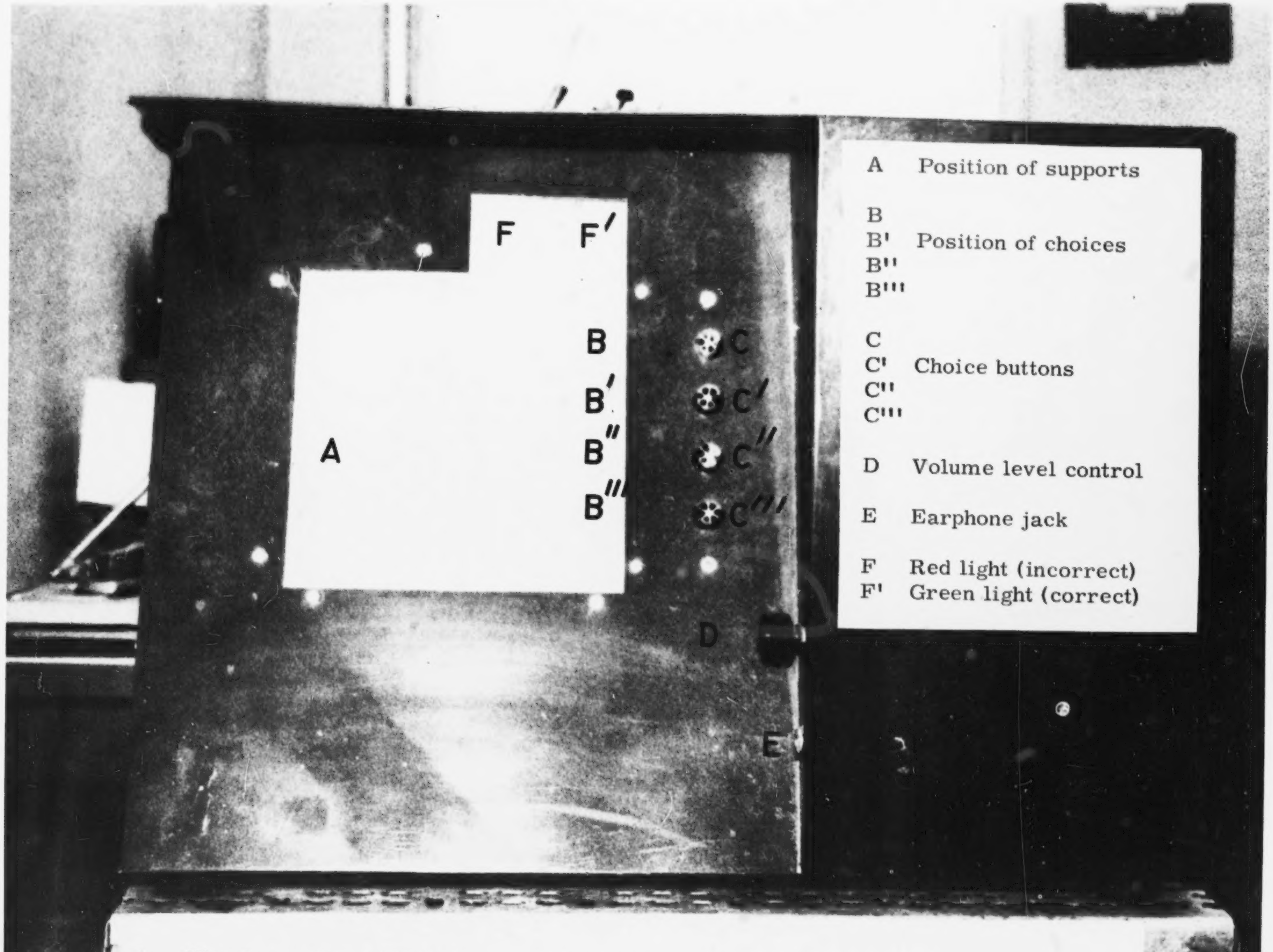

A Position of supports
B
B' Position of choices
B''
B'''
C
C' Choice buttons
C''
C'''
D Volume level control
E Earphone jack
F Red light (incorrect)
F' Green light (correct)
F
F'
A
B
B'
B''
B'''
C
C'
C''
C'''
D
E

Fig. 3.1. Front (S's) view, screen positions and response buttons.

Optical. The basic unit in the optical system is an electromechanically advanced Duquesne single frame 35mm strip film projector. Loading of film on this projector might be described as "semi cartridge". The film is removed from the storage can (described elsewhere) and placed in a magazine. From this magazine it is fed through the projector to a rewind device, where it is automatically rewound for further use (see Fig. 3.2).

Because of space limitations within the cabinet, an ingenious "folded" optical system (Fig. 3.3) is used to provide proper enlargement of the image on the screen. By the use of three first-surface mirrors, the projector beam is bent through approximately 270° (three approximately 90° bends). Each of these mirrors is provided with adjustments, the first two with four point adjustment, the third with three point. These adjustments allow for pinpointing the image from the film on the screen.

The optical system, by means of photocell coding on the edge of each film frame, supplies information to the machine on which of the buttons is next to the correct choice for that frame. This is done by means of a binary code which functions as follows:

Dark-Dark-1 - Top choice correct
Dark-Light-2 - Choice next to top correct
Light-Dark-3 - Choice next to bottom correct
Light-Light-4 - Bottom choice correct

This function is carried out by the top photocells (Fig. 3.4). The bottom photocells (installed in the research model only) serve a readout purpose to be explained below in the electronics section.

Mechanical. The mechanical section of the teaching machine is concerned only with film and tape advance and with tape rewind. This film advance is carried out conventionally by means of a clutch/sprocket arrangement. Advance may be carried out in two ways: 1) automatically, by means of a pulsed electric motor activating a lever system; and 2) manually. The automatic advance mechanism is returned to the ready state by means of a spring return and clutch arrangement. The manual advance may be backed up for framing by depressing the advance knob and turning it backward.

The automatic rewind feature (Fig. 3.2) prepares the film for immediate reuse. Loading of film is accomplished by placing it in a shallow cup and feeding it through the projector from the inside of the roll. This is entirely conventional.

The tape playback feature (Fig. 3.5) is entirely conventional. Tape rewind is by means of a knob on the lower right hand side of the recorder panel.

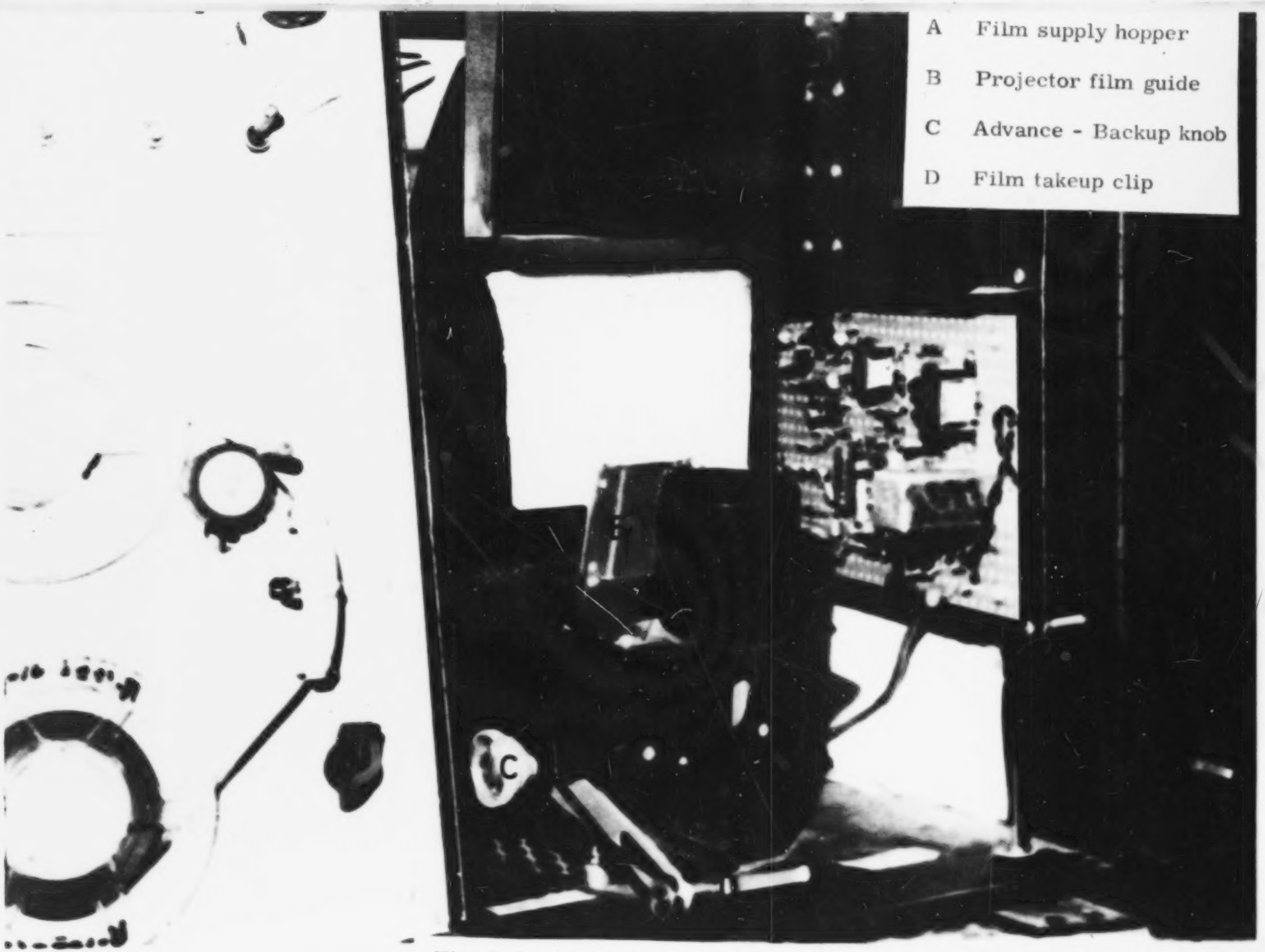
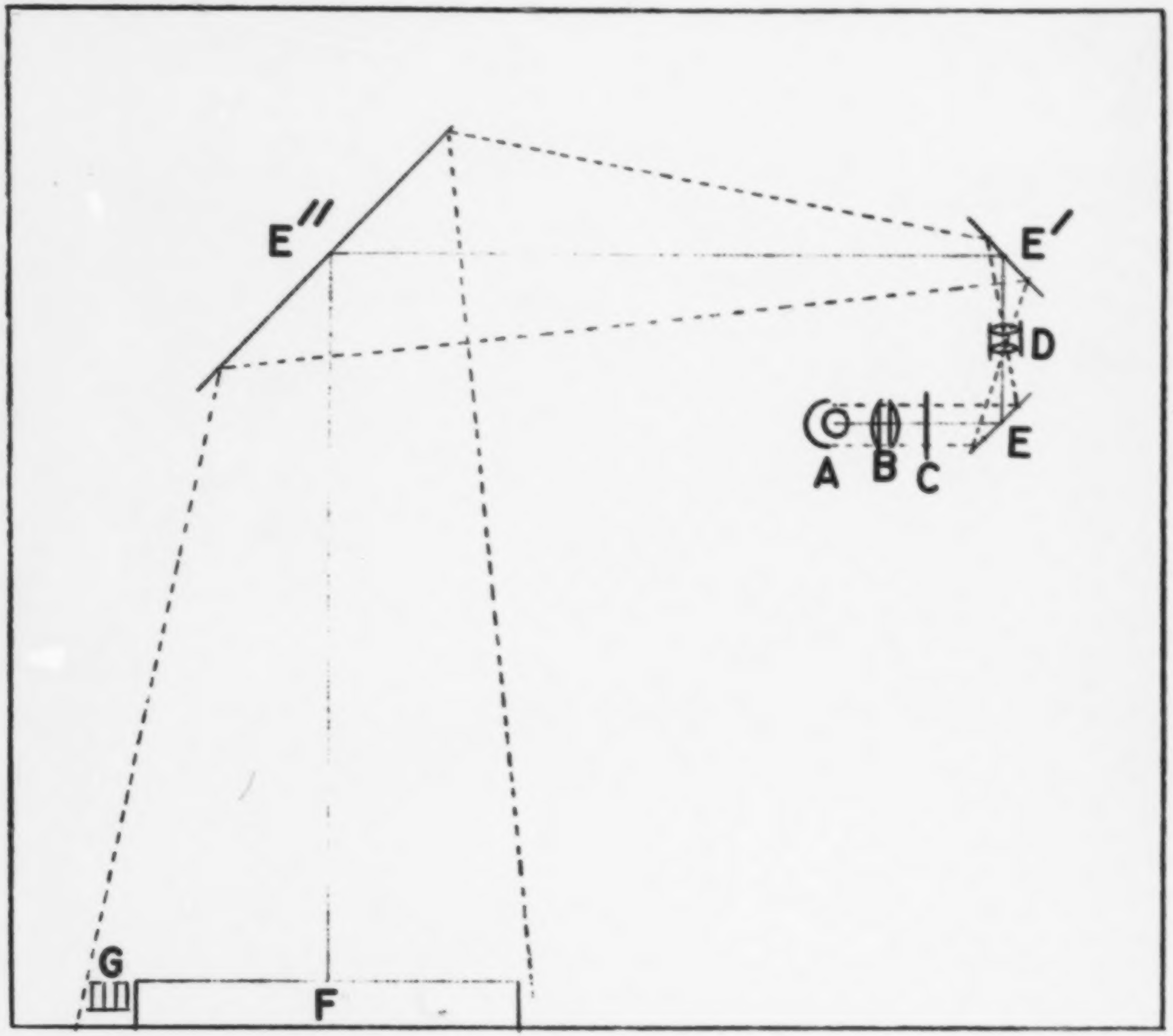
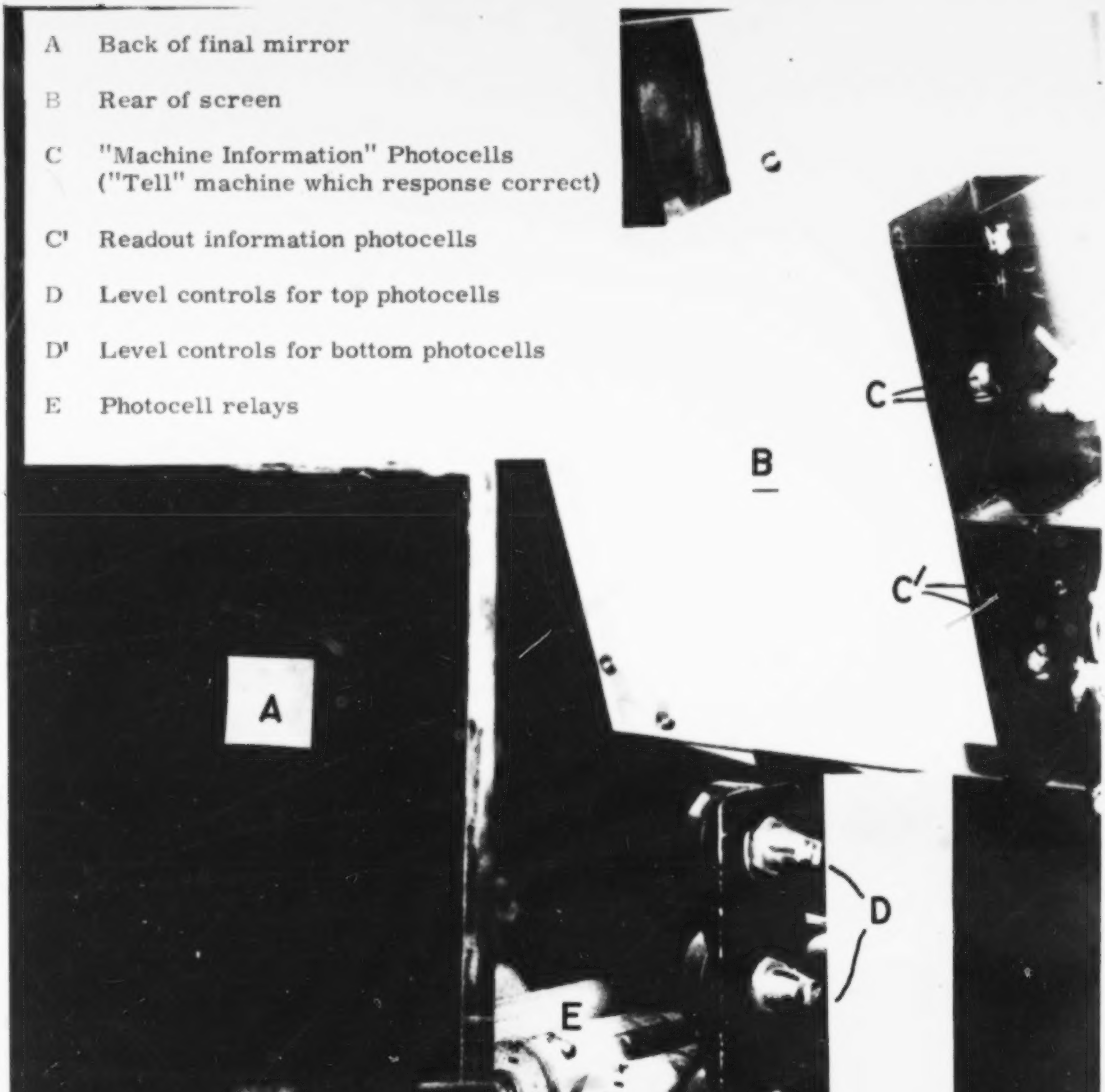

A Film supply hopper
B Projector film guide
C Advance - Backup knob
D Film takeup clip
C

Fig. 3.2. Projector mechanical details.



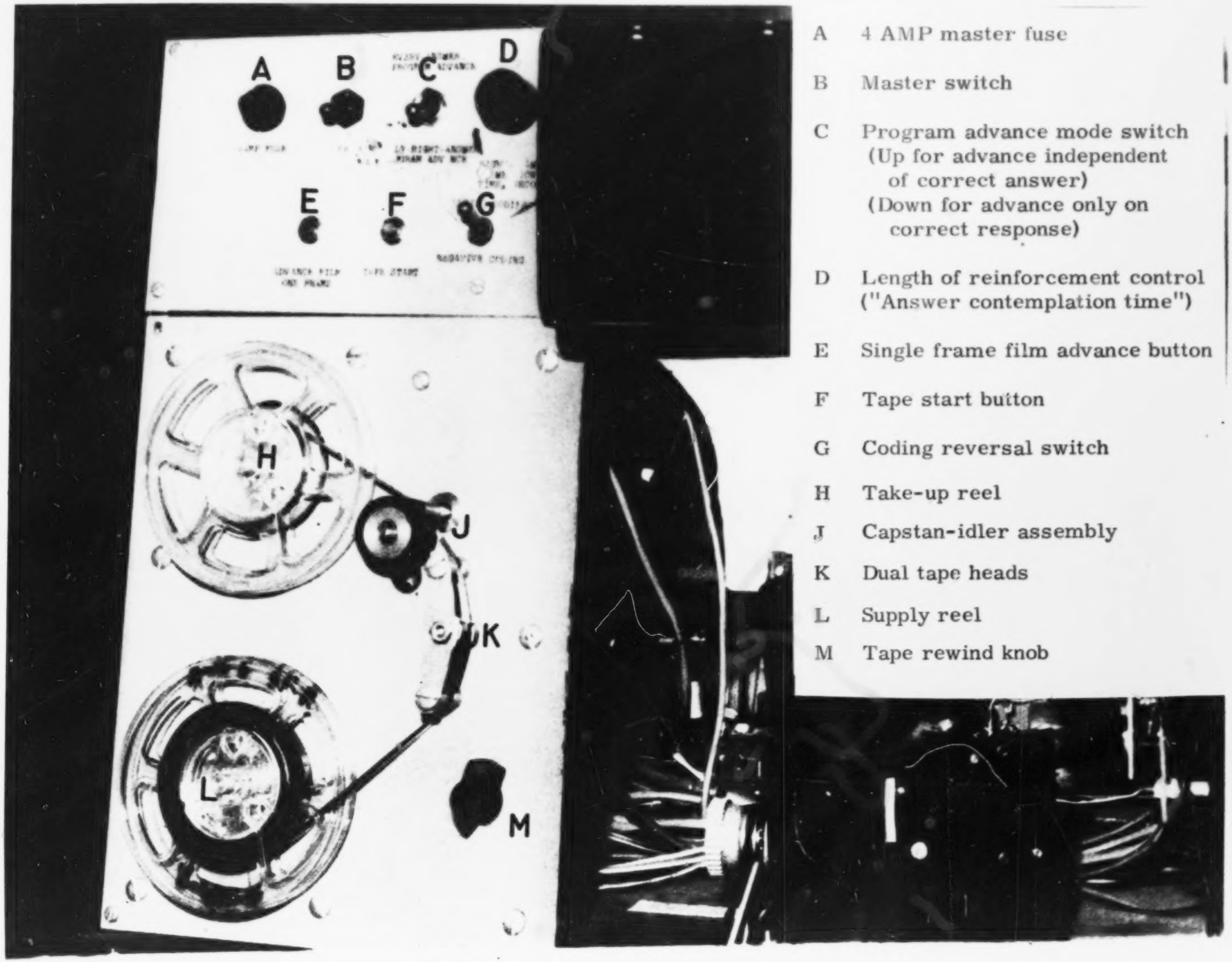
A	Lamp-reflector assembly
B	Condenser lens
C	Film plane
D	Compound projection lens
E E' E''	First surface mirrors of "folded" optical system
F	Screen
G	Photocell assembly

Fig. 3.3. Diagram of optical system (top view).



A	Back of final mirror
B	Rear of screen
C	"Machine Information" Photocells ("Tell" machine which response correct)
C'	Readout information photocells
D	Level controls for top photocells
D'	Level controls for bottom photocells
E	Photocell relays

Fig. 3.4. Photocells and controls



A	4 AMP master fuse
B	Master switch
C	Program advance mode switch (Up for advance independent of correct answer) (Down for advance only on correct response)
D	Length of reinforcement control ("Answer contemplation time")
E	Single frame film advance button
F	Tape start button
G	Coding reversal switch
H	Take-up reel
J	Capstan-idler assembly
K	Dual tape heads
L	Supply reel
M	Tape rewind knob

Fig. 3.5. Control panel and tape deck.

Electronics. The electronics circuits (Schematic Diagram) will be treated as follows (in "order of appearance" in a typical frame):

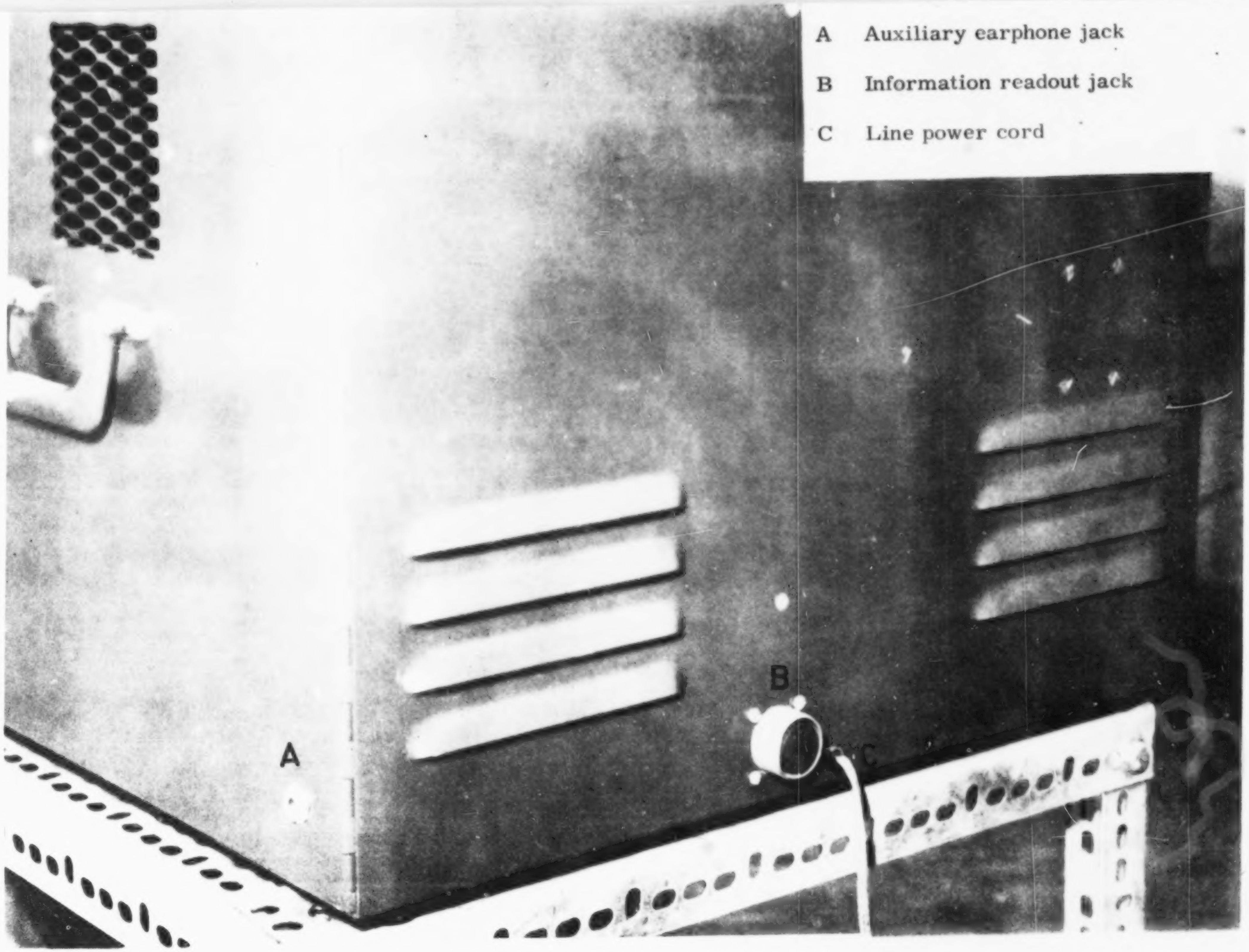
1) Tape information track circuit
2) Tape stop track circuit
3) Photocell circuit for information to machine on "correct" button
3a) Readout circuit on machine information
4) Subject response circuit
4a) Readout circuit on S response
5) Subject "feedback" circuit (red and green lights)
5a) Readout circuit on "feedback"
5b) Circuit for tangible reinforcement of S
6) General description of readout circuits and connector
7) Film advance circuit
7a) Tape start circuit
7b) Button reset circuit

Tape Information Track Circuit. This is a straightforward circuit, in which output from one track of a pre-recorded tape is fed into a four transistor amplifier of conventional design. Output is through a 500 secondary transformer (to match the impedance of the earphones) through two jacks. One of these jacks (Fig. 3.1) is for the use of the S, the other for monitoring by E (Fig. 3.6). A volume control (Fig. 3.1) is included to adjust for individual Ss. Power for the amplifier is from a regulated, well filtered power supply.

Tape Stop Track Circuit. This circuit, which is a three stage transistor amplifier, is activated by a pre-recorded 1000 cycle tone on the tape track opposite the information track. Activation of this amplifier causes it to drive a normally closed relay to the open position. Opening of this relay interrupts the tape drive solenoid circuit, at which point the tape stops. To insure that the small residual tone remaining will not stop the tape immediately after restart (on the next frame) a time delay circuit, consisting of a one microforad capacitor and a 47OK resistor is placed in the input of this circuit.

Photocell "Machine Information" Circuit. This circuit "tells" the machine, on the basis of light supplied or not supplied from photocell coding spots on the margin of each film frame, the correct button to be pushed for a particular frame.

Type CL404 (Clairex) photoresistive cells (Fig. 3.4) are used. These have a very high resistence in darkness which drops to a very low value when light strikes the photosensitive surface. Thus, the



A Auxiliary earphone jack

B Information readout jack

C Line power cord

Fig. 3.6. Information output jack.

circuit may be said to be "off" in darkness and "on" in light. A 50k resistor in series with each photocell allows adjustment for lamp aging, film density variations etc. When the photocell circuit is in the "on" condition, it activates a relay (advance RA-12) through a simple two stage transistor amplifier. This "on-off" characteristic of the photocell amplifier relay circuit makes possible the use of a simple binary code (light=on=1, dark 0), combinations of which, through series circuits of the relay contacts with the push buttons next to screen "tell" the machine which push button is correct. This code is illustrated in the following Table:

Table 3.1

State of P.C. 1	State of P.C. 2	Binary Code	Correct Button
off	off	0-0	1
off	on	0-1	2
on	off	1-0	3
on	on	1-1	4

An ingenious switching arrangement, set by throwing a single switch on the control panel, Fig. 3.5 reverses the connections to the push buttons and effectively, reverses the above Table, so that negative strips of the programs may be used with the machine, as well as positives.

Readout information on the correct button for a particular frame may be had from several of the machines. As this feature will be described in detail below it is simply mentioned here as a part of the general "machine information" circuit.

Subject Response Circuit. This circuit is activated by the S's pushing of a button. These buttons (Fig. 3.1) are, as mentioned above, connected in series with the "machine information" relays. They are automatically reset when the program advances (see below for mechanism). Briefly, if the S makes an incorrect response he sees a red light above the screen (See Fig. 3.1), if he makes a correct response he sees a green light and the program advances to the next frame. The mechanisms and circuits for these lights and changes will be discussed below.

As in the "machine information" circuit, readout on S responses is also available. This will be discussed more fully below.

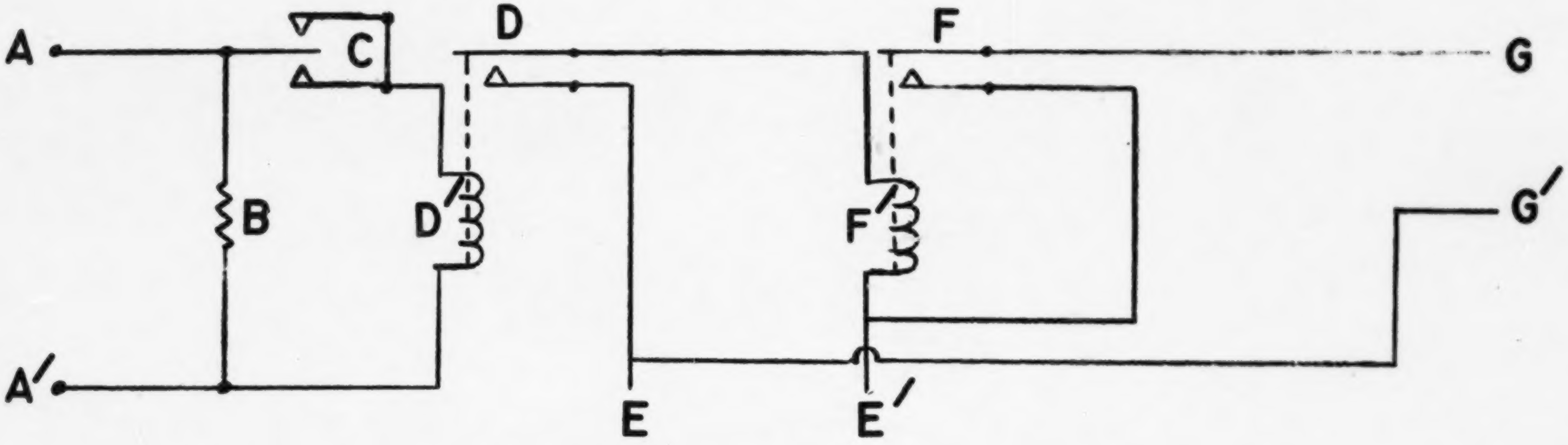
Subject "Feedback" Circuit. This circuit gives information on the correctness of his answer to the S, by lighting the red or green light mentioned above. The circuit for these lights is tied into the "machine information" circuit mentioned above. The length of time the light stays on (1-3 sec.) can be adjusted from the control panel (Fig.3.5) by means of the "answer contemplation time" control. This "contemplation time" is controlled by a resistor-capacitor timing circuit through a latching relay. At the end of the "contemplation time" period, the latching relay drops out and initiates the next steps (see below).

If the S is correct, the circuit insures that he will get an advance to the next program frame. If he is incorrect, a holding feature prevents the tape start and film advance mechanisms from operating. This incorrect response holding feature may be defeated, if desired, by the "program n advance mode" switch on the panel (see Fig.3.5) so that every response, right or wrong, causes the program to advance. A correct response on the part of S feeds a 24VDC, 100MA pulse through a pin readout plug (Fig.3.6) The pulse, which continues until the response button is reset may be used to operate a plate current relay (Such as a Sigma 4-F or 5-F). This relay, in turn may be used to sound a buzzer or bell or to operate a reward device. In the experiment on tangible reinforcement, this pulse was used to operate a small 9K relay, which in turn operated a larger 12VDC relay (Fig.3.7). This larger relay (with contacts sufficient to handle the 5 amps necessary) was used to operate a Davis Scientific Instruments MMD-1 candy dispenser. The 9K relay's circuit was broken by an SPDT switch, spring loaded "off" to the center from one position, so that, by selection of switch position, E could leave it on for a 100% reward condition or "program" it on randomly for 25% reward condition. The 15K resistor was inserted in parallel with the 9K relay to bleed off the capacitor's charge after correct non-rewarded responses in the 25% reward condition.

Readout Plug (Amphenol MS-31024). Provision is made in several of the machines for reading out, on an Esterline Angus industrial event recorder, information on stimuli and responses (Fig.3.6). This information may be categorized as follows:

1) Information on "information" from the program to the machine.
2) Information on the stimuli being presented to S on each individual frame.
3) Information on S's responses for each individual frame.
4) Information on S's correct responses, hence on change of frame.

Table 3.2 shows the connections on the machine's readout connector. In Category 1, information may be obtained on which response button is correct for each individual frame. This information is taken from the above mentioned "machine information" photocells, is fed out as -24 voltage on pins K, L, M, and N of machine's readout connector, with positive return on pin R.



A	Pin "A" (-24VDC)Amphenol connector MS
A'	Pin "P" (+24VDC)3102A on back of machine
B	15K, 1/2 watt bleeder resistor
C	SPDT switch, spring loaded "off" from one position
D	Contacts } 9K plate current relay
D'	Coil
E	+15VDC } From EICO 1060 battery eliminator
E'	-15VDC
F	Contacts } 12 volt slave relay
F'	Coil
G	Power output to Davis instruments MMD-1 reward dispenser
G'	

Fig. 3.7. Schematic diagram of tangible controls reinforcement device.

Table 3.2

Complete Readout Plug Connections

Amphenol Connector MS 3102A 16 Pins

Letter	Function
A	Ground, return for auxiliary photocells' relay; also push-button readout return.
B	Auxiliary Photocell circuit's output 1 1 (1)
C	Auxiliary Photocell circuit's output 0 1 (2)
D	Auxiliary Photocell circuit's output 1 0 (3)
E	Auxiliary Photocell circuit's output 0 0 (4)
F	Push button No. 1 Normally Open Contact
G	Push button No. 2 Normally Open Contact
H	Push button No. 3 Normally Open Contact
J	Push button No. 4 Normally Open Contact
K	−24 Volts DC if No. 1 PB is correct for particular frame
L	−24 Volts DC if No. 2 PB is correct for particular frame
M	−24 Volts DC if No. 3 PB is correct for particular frame
N	−24 Volts DC if No. 4 PB is correct for particular frame
P	24 Volts DC if right button is pushed
R	Return for K, L, M, N only
S	No connections
T	No function

CONNECTOR OMITS CERTAIN LETTERS

0 0, 1 0, 0 1, 1 1 defined from front view of machine

0 absence of light

1 presence of light

In Category 2, the auxiliary photocells function through transistor amplifier driven relays and external battery power (24VDC) to provide information on which of four words, sentences, problems, etc., is being taught. These stimuli are arbitrarily assigned a number from one to four and the programs coded accordingly using the above mentioned binary code. Pins B, C, D, and E are used for this information, with ground return to Pin A.

In Category 3, contacts on the response buttons close a circuit from the above mentioned 24VDC external power source to record which button is pressed by S on each trial. Pins F, G, H, and J are used for this information, with ground return to pin A.

In Category 3a, the 24VDC pulse, mentioned above in connection with the tangible reinforcement device, is used to drive the pen. This mark on the record indicated the end of a frame. Pin P is used for this function with return to pin A.

Thus, on a typical record from the events recorder, E has complete information of S and machine performance. An additional advantage is that, since the paper in the recorder is driven at a constant rate by a synchronous motor, E has a record of S's response latency.

Film Advance-Tape Start-Button Reset Circuit. A correct response by S triggers a 2D21W thyratron tube (an all-or-none arrangement). This tube then functions through relays to (1) kick the film advance motor, (2) reset the button to the ready position and (3) pull in and hold the tape playback solenoid. At this point the subject sees and hears the next frame of the program.

See Appendix E for detailed wiring diagram of teaching machine.

Chapter 4

Program Production and Library Unit

Michael J. M. East

The function of this unit was to transcribe the rough handwritten program material into finished programs or lessons which could be used in the teaching machine. Since the goals of the project were to develop a machine and programs capable of teaching beginning reading and arithmetic, the usual one channel (visual) machine would have been inadequate. Therefore, an audio channel was included to present that portion of information which, with a more advanced type of subject matter, could be presented visually in writing. For this task, standard magnetic recording taype was used. The final model of the teaching machine included only a tape deck for playback rather than a complete recording machine. Due to the logistical problems involved in presenting the visual material on paper or cards and the problems of mechanically manipulating paper or cards, 35mm micro film strips were ultimately chosen for the visual portion.

The first attempt at a system for delivering the visual information was a device for moving and presenting 5" x 8" cards, one at a time, (see Fig. 4.1). However, it soon became apparent that the development of a device that could perform this task reliably would require more time and money than was available. A commercially available card moving device, "The Hunter Card Master" was tried, but also found to lack sufficient reliability of operation.

The second machine produced in the developmental sequence was a console type which stands on the floor, while the final model is portable and may be placed on a table, (see Fig. 4.2 and 4.3). Whereas the operation of the two machines is almost identical, there are a number of technical differences.

Figure 4.4 is a view of the inside of the prototype machine cabinet. Most of the components of the prototype machine are commercially available, while their counterparts in the final machine were developed and built specifically for it. This is one reason for the reduction in overall machine size.

Technical aspects of program production.

After receiving the program material from the writers, it was transcribed onto one of two sizes of index cards. For the word programs, 4 x 6 inch cards were used, (see Fig. 4.5). Each card represents two frames. The words to be learned were typewritten inside the arrow outline. Where cue words (or prompts) were used, they were typed on the line on the left of the arrows. Then, slips of paper bearing the audio script were glued to the back of each card. The

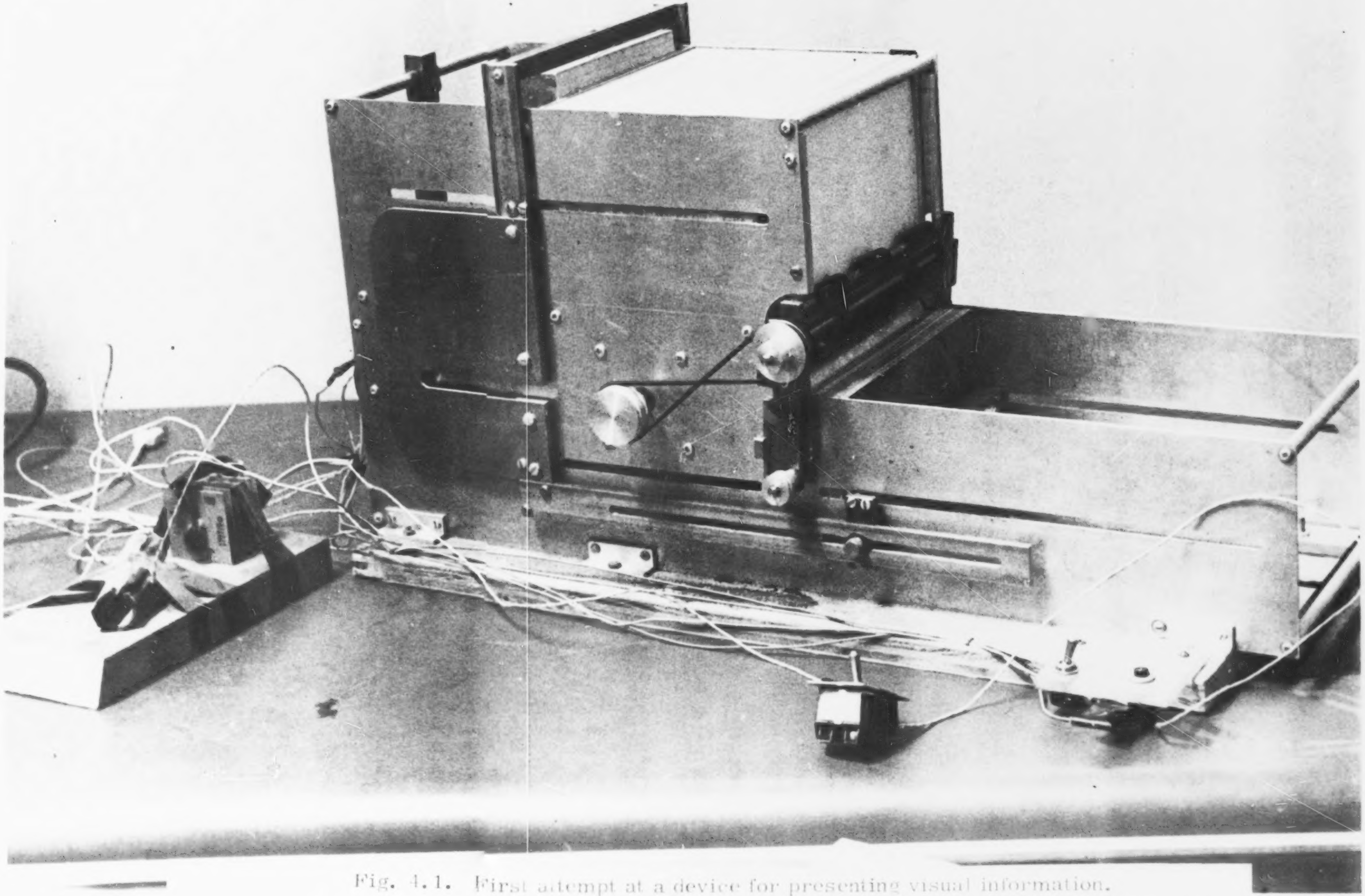


Fig. 4.1. First attempt at a device for presenting visual information.

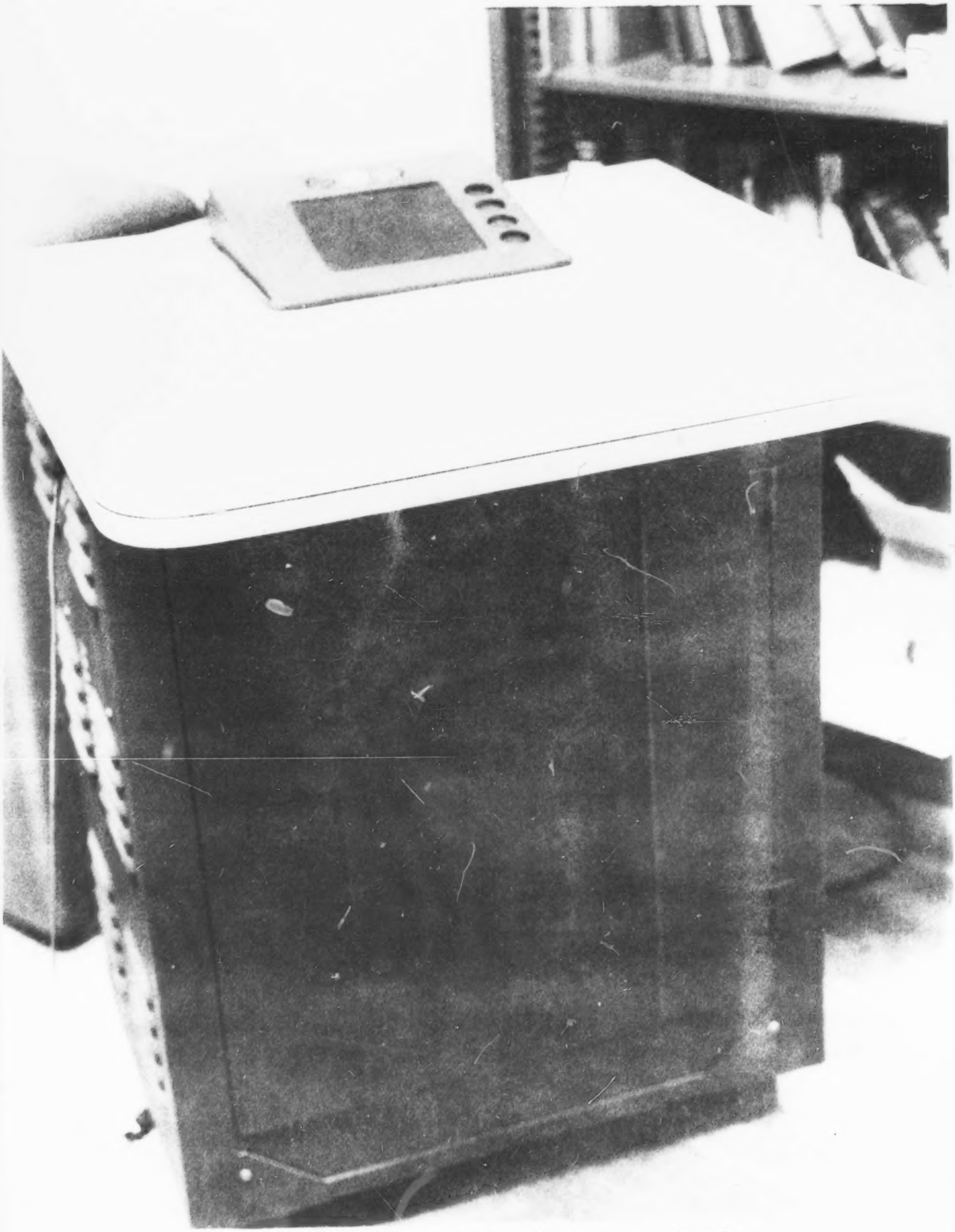


Fig. 4.2. Prototype of the Teaching Machine.

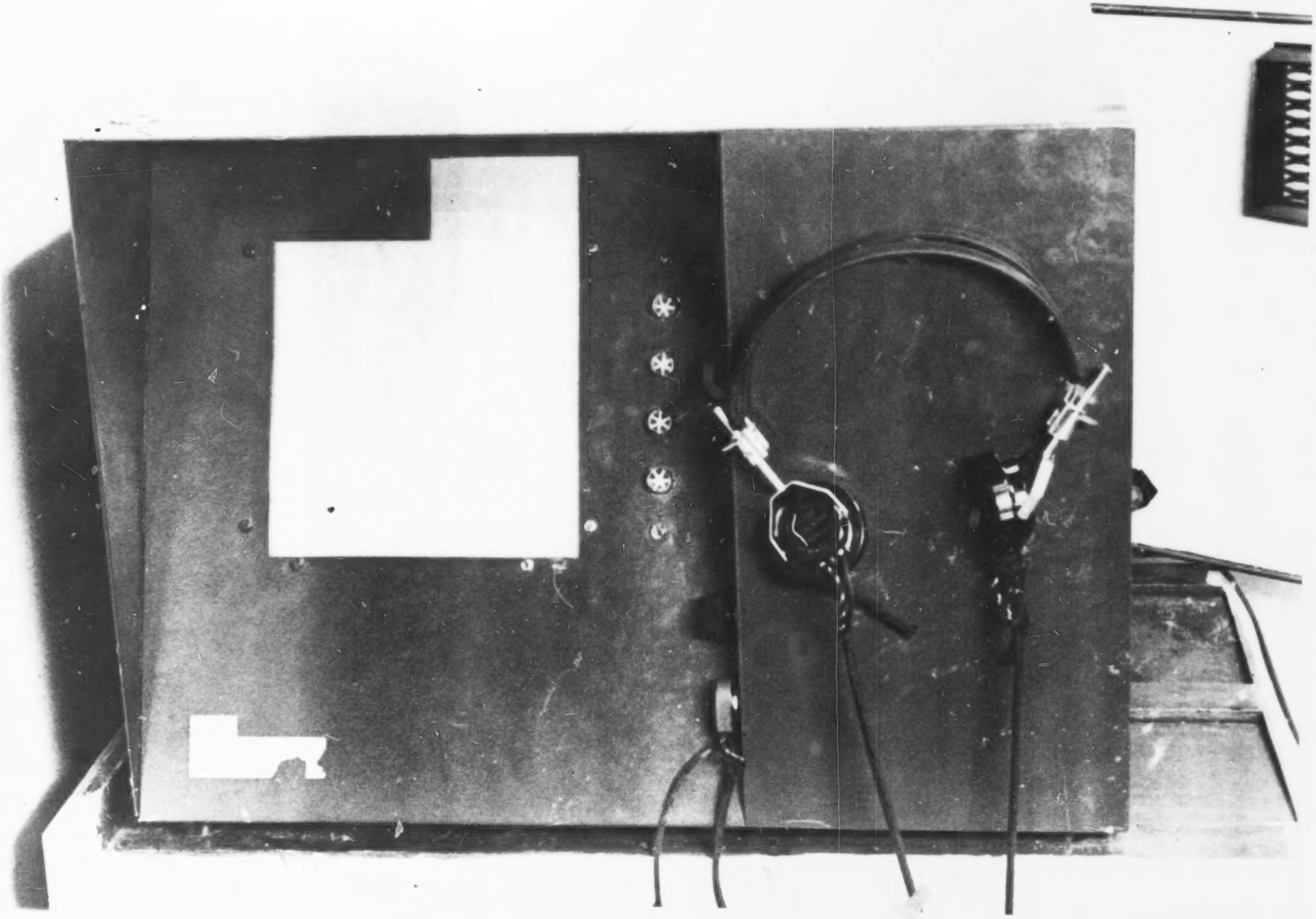


Fig. 4.3. The final version of the Teaching Machine.

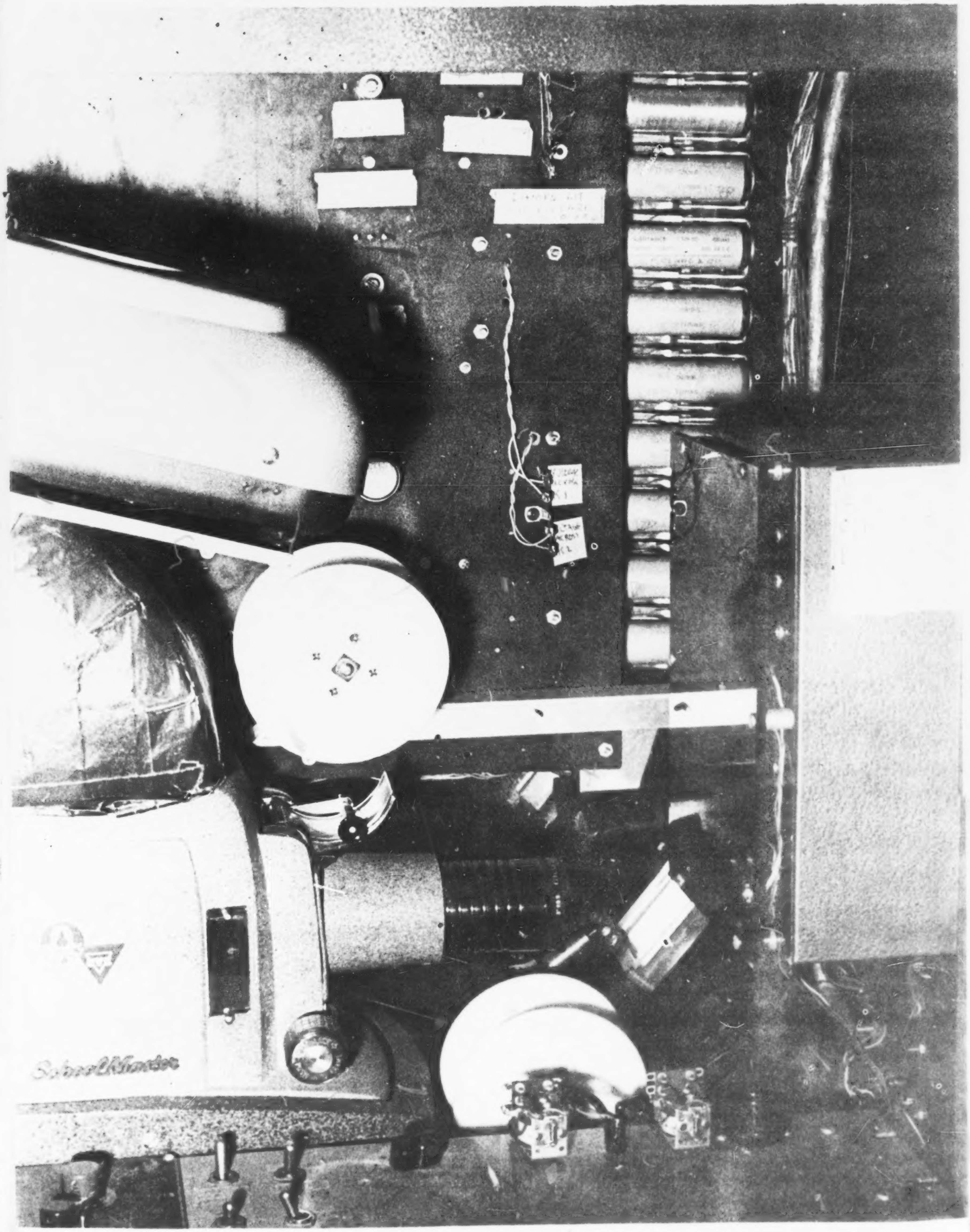

Schoolmaster

Fig. 4.4. View of prototype machine with access door open.

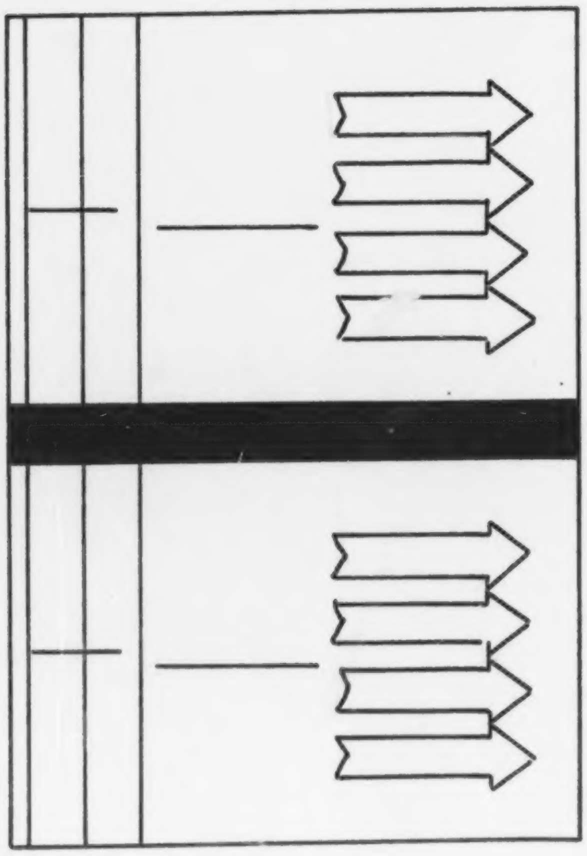


Fig. 4.5. Photographic format for word programs.

coding marks were made with Marks-a-Lot marking pencils. The front portion of the cards were then photographed by slipping the cards one at a time into a jig on the copy stand, (see Fig. 4.6).

For sentence, arithmetic, and phonics programs, 6 x 8 inch cards were used. The process is the same for the large cards, only the materials differ. Figre 4.7 is a copy of the large master card. It is the final photographic format.

Two types of small cards were used, one of which is Fig. 4. 5 and one on which the arrows are eliminated, (see Fig. 4. 8).

For each program a set of master cards was prepared which included all the information to be presented to the student by the teaching machine. Each card holds two frames. On the front of the card is the visual display and on the back is the information the student hears through the earphones. Also included is the coded information to the teaching machine "telling it" which button position the correct response is in so that proper feedback may be administered; and which word in the original list the correct response is so that the recording device can record not only the number of correct and incorrect responses but also which stimuli were responded to correctly or incorrectly. Figure 4.9 is identical to Fig. 4. 7 except that the various areas have been labeled for reference. Figures 4.7 and 4.8 differ only in size. The area of the card labeled "A" is the space where the visual information is typed. It represents the teaching machine viewing screen. Lines 1, 2, 3, and 4 mark the areas which correspond to the choice buttons on the teaching machine. The alternatives from which the student must choose are typed by these lines to the left of the vertical margin. This takes up approximately half of Area A, leaving the left half for prompting material.

Whereas B, C, D, and E do not appear on the teaching machine screen, they do appear on the film. When areas B, C, D, and E are white on the card and clear on the film strip, light passes through them and strikes the photo electric cells. The machine's reaction to the activation of these photo cells is described under the section entitled "Technical Descriptions of the Teaching Machine."

Areas D and E are used only when the machine is to function in a laboratory situation. They are used to indicate to a laboratory recording device which word is the correct alternative on each frame. These data are collected in order to provide error rates for any particular word being taught. The coding system works in the same way as that described for the correct button position code, only it refers to an arbitrary position of the word in a list of words being taught by that particular program, instead of the button position of that word on that frame. This code system is also described in an earlier section.

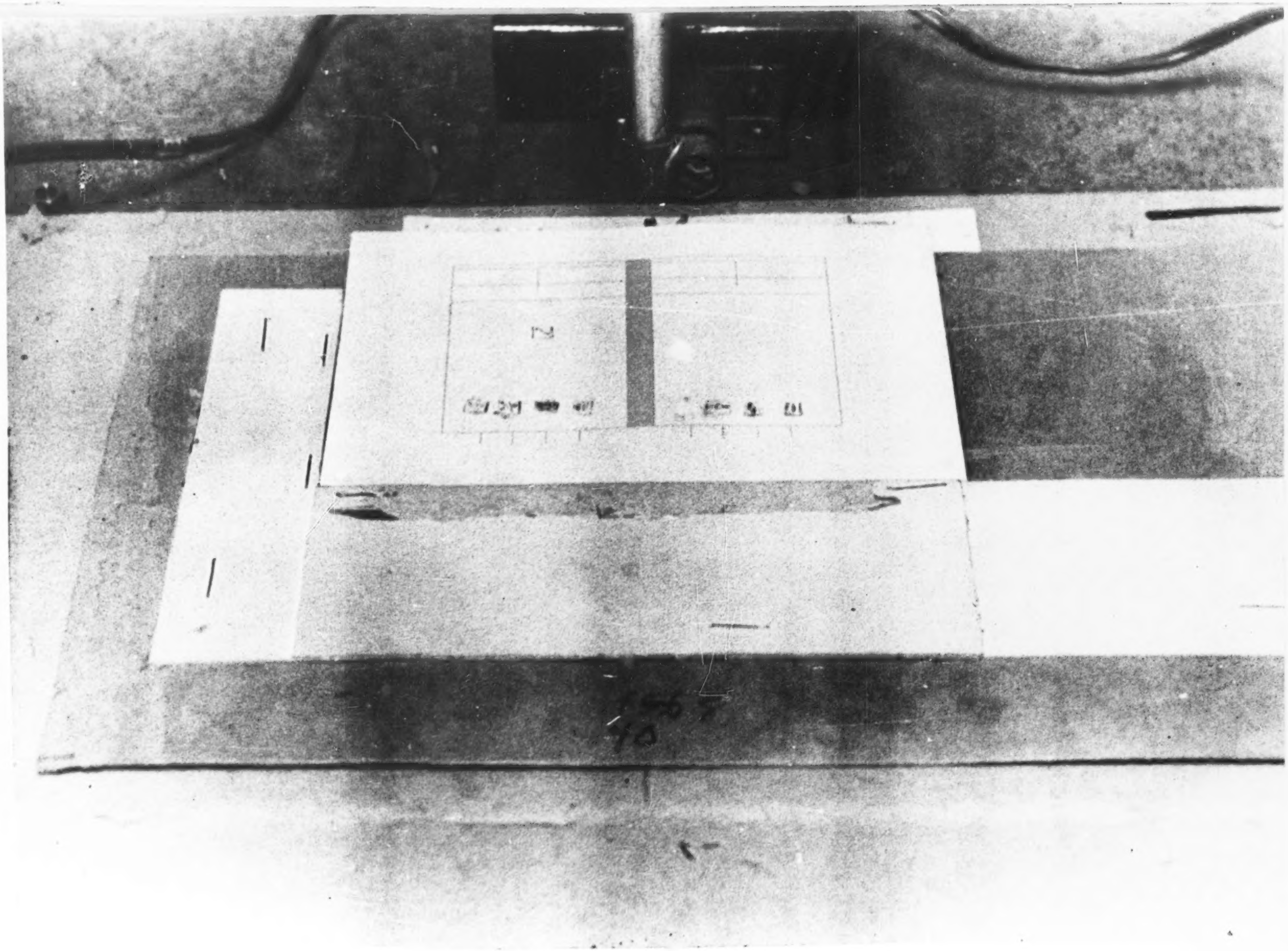


Fig. 4,6. Photographic format in place under the camera.

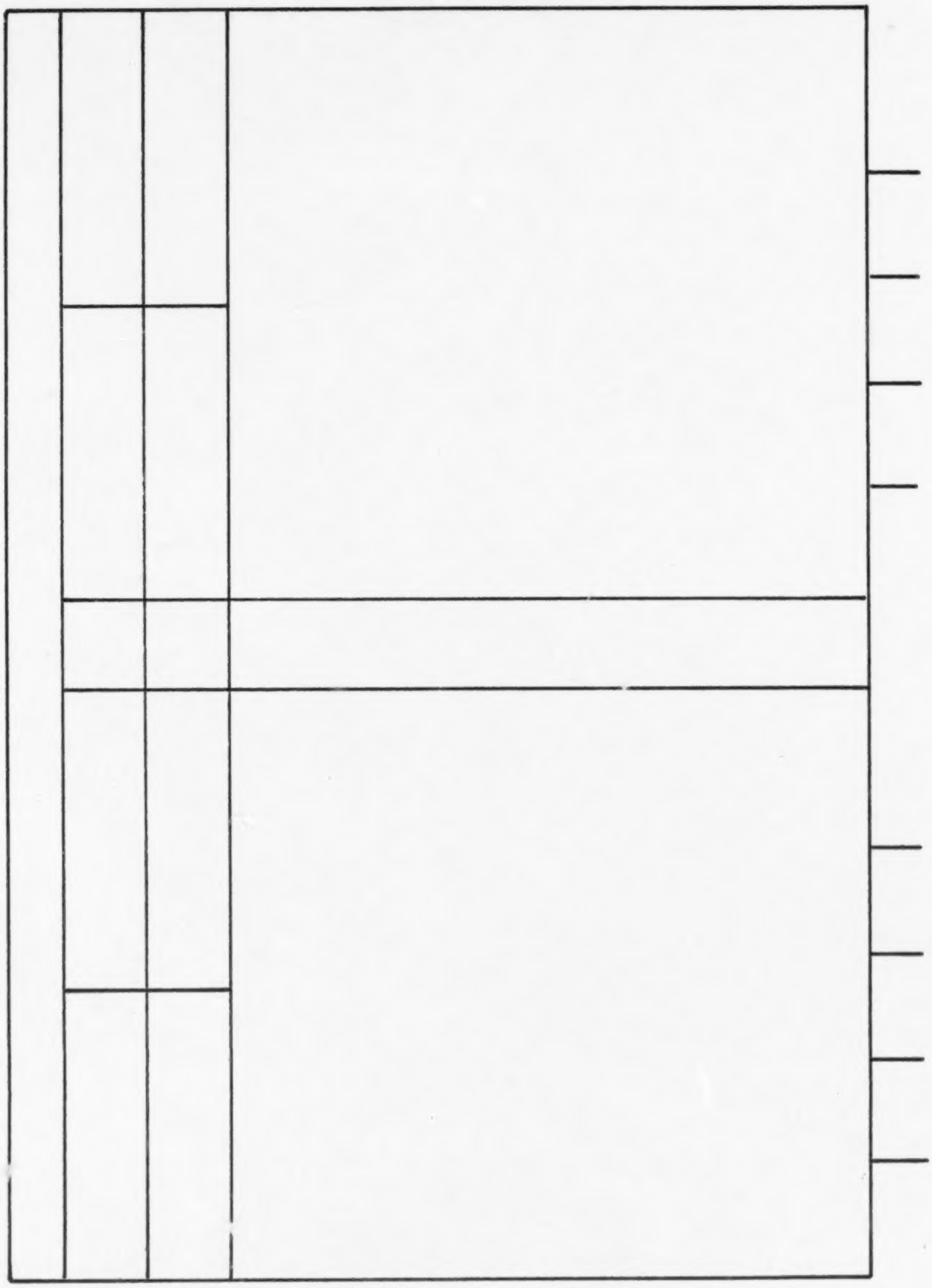


Fig. 4.7. Photographic format for sentence, arithmetic and phonic programs.

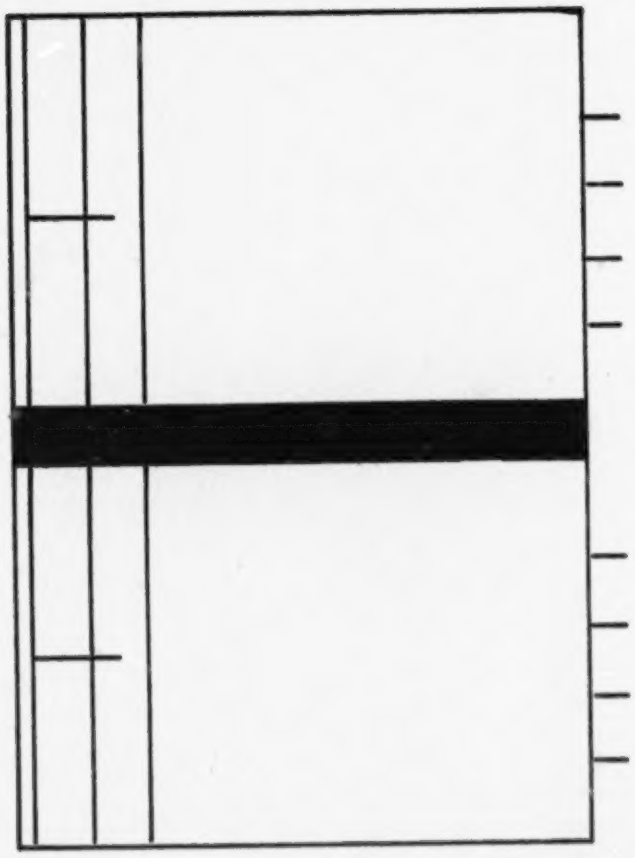


Fig. 4.8. Small photographic format without arrows.

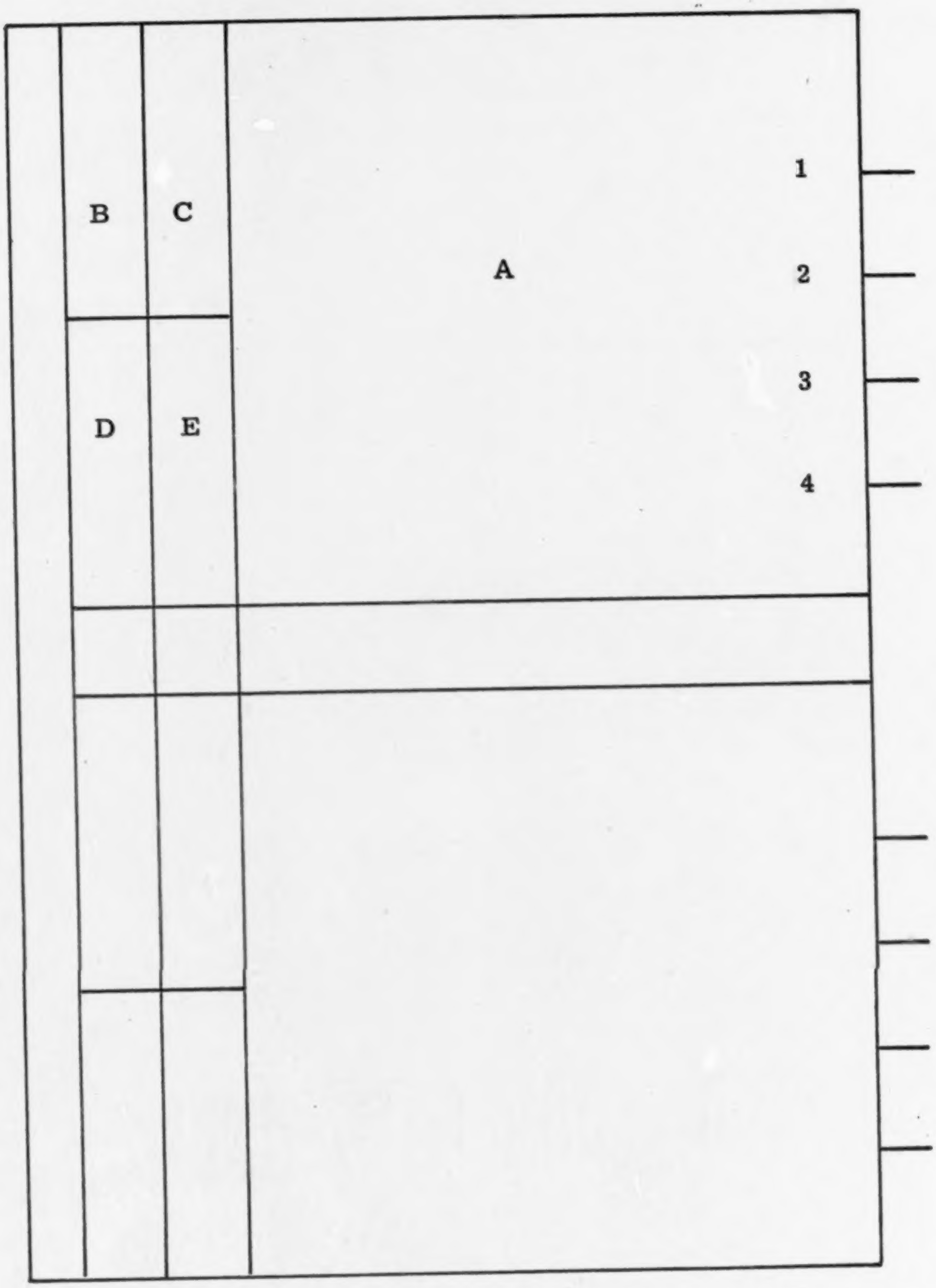


Fig. 4.9. Refer to text for explanation of labeled areas.

Several systems of coding, spot marking, were tried before one was finally adopted. The first was to place rectangular pieces of black paper on the card in the correct position before each card was photographed. The small pieces of paper, however, were quite hard to handle and the process was very slow. Next, rectangular shaped pieces of lucite, painted black, were used. These were easier to handle but still slowed down the photographic procedure. And additional disadvantage to this type of system is that if the program has to be re-photographed, the coding has to be done each time. A procedure used in filming for the prototype machine, which required a different format because of a different positioning of the photo cells, involved a system of hinges, painted black which could be moved in or out of the photographed area, (see Fig. 4.10) This was much faster than the two preceding methods but as before was still not permanent. A further disadvantage of this, is that when the coding is done during the photographic procedure, there is much more room for error, due to the interference from the many other activities involved in the photography itself. When the coding is put permanently on the format, the coder can concentrate on that one activity. Also, it allows for independent checking of correctness before photography.

A fifth system was considered but rejected. The coding could be done directly on the negative film strip by punching holes in it, allowing light to pass thru, which would create black spots on the positive copies. This was rejected because of the difficulty of obtaining precision of spacing on such small materials as 35mm film. The solution, as stated previously, was to apply the code marks permanently to the cards before photography.

The photographic formats were established roughly through arithmetic calculation and modified empirically, i.e., when it was decided that the small format should fit on a 3 x 5 index card, the camera reduction and projection enlargement ratios were considered and the outline of the photographic area was estimated arithmetically. An outline was hand-drawn with the estimated boundaries and button positions. This was photographed, processed and project on the machine itself. Minor corrections of borders and button positions were made until the format fit the machine perfectly. This hand-drawn format was then reproduced in large quantities by photo-offset printing.

In addition to the ease of handling during photography, the cards have the advantage of being an accurate paper record of each program. A condensed record of each program was made up by the program writers on the form which is Fig. 4.11.

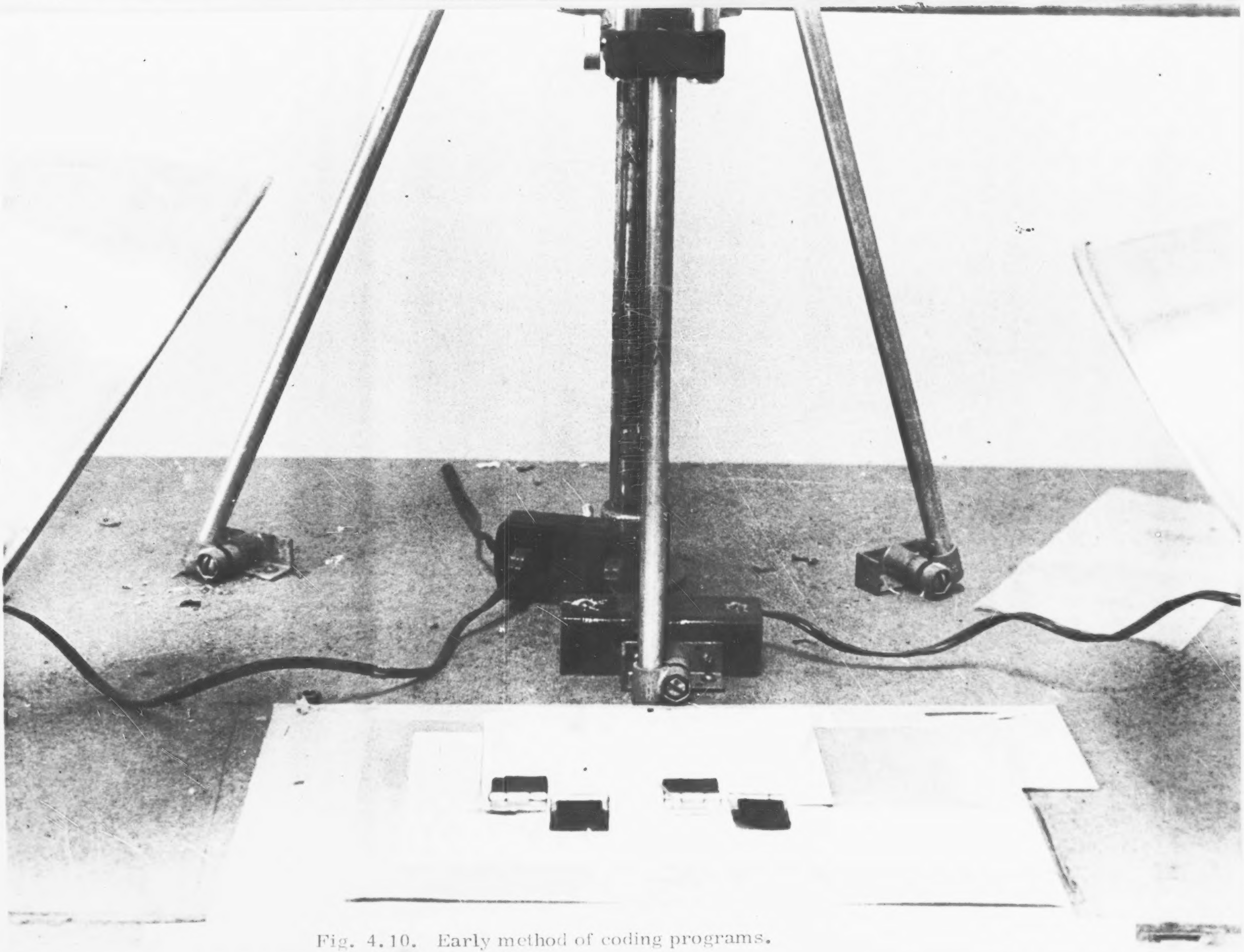


Fig. 4.10. Early method of coding programs.

Program Title and number Word Recognition No. R-4

Purpose Teach four (4) words

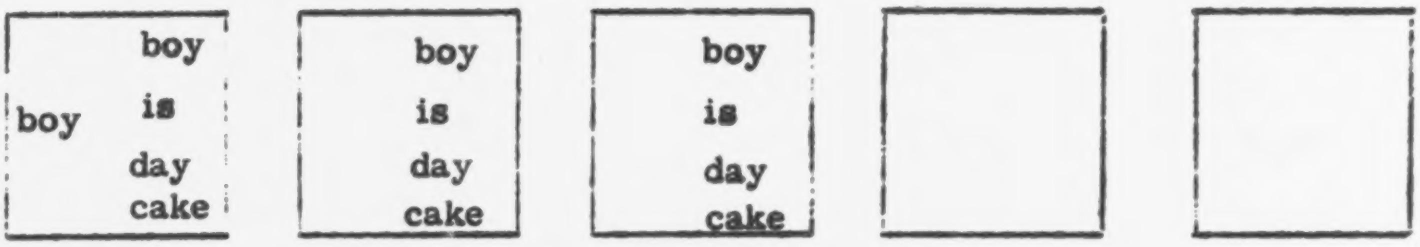
Authors F-T-B

Number of new items taught by one complete runthrough 4

List new items taught (e.g. cat, dog, ball, rat) and number of presentations of each item boy, is, day, cake

Total number of frames 44

Draw each separate type of item, write the number of times it appears, and instructions that go with it.



# A	# B	# C	#	#
Instructions	Instructions	Instructions	Instructions	Instructions
Read word on left	Read alternatives	Press boy		
Read alternatives	Press boy			
Press boy				

Remarks: (Describe item sequence)

See TMP No. 1

Fig. 4.11. Condensed record of a program.

Film strips and tape recordings were produced for the prototype machine in essentially the same manner as those described for the final model. The only two procedural differences were that the photographic formats differ slightly, and the tape recording was done directly on the recorder in the prototype teaching machine. Figure 4.12 is a copy of the format used with the prototype machine. It will be noticed that the only significant difference is in the number and location of coding spots, areas B and C which correspond to B and C on Fig. 4.8 There are two reasons for this difference. The photo cells on the earlier machine are located below the viewing screen while on the final model they are located at the side of the screen. A second reason for this difference was that the optical systems in the two machines different in the number of reversals made in projection.

The prototype machine is sensitive to periods of complete silence on the tape rather than a high frequency tone as is the case with the final machine. Thus, when a certain amount of blank tape has gone through, the machine shuts off automatically. The viewing screen on the final machine is slightly larger than that of the earlier machine. One is 5 inches square while the other is 6 3/4 inches square.

The camera used to photograph the program was a 35mm Nikon "F" Automatic Reflex. Three copying stands were used. The first was a commercially available stand produced by Rowi. This was found to be unsatisfactory and was replaced by two copying stands built by the writer to satisfy the needs of this particular copying task.

The first of these stands was built around a bellows focusing attachment for the Nikon "F". The framework was constructed from chemistry laboratory apparatus mounts, and was attached permanently to a bench top (see Fig. 4. 13).

The second stand is quite similar, except that instead of a bellows attachment the camera is bolted to the stand and extension tubes are used between the camera and the lens. The stand is mounted on a baseboard which is portable. (see Fig.4.14) The second stand was necessary because the large cards used for sentence and arithmetic programs are larger than can be photographed on the first stand.

The film used for this photograph is Kodak High Contrast Copy (previously known as Micro-File). The film was purchased in 100 foot rolls and loaded into empty thirty-six exposure cartridges with a Watson Model 66 day-light bulk film loader. After the film was exposed, it was sent to Photo Arts, Inc., Trenton, New Jersey for processing. When returned as negatives, the film strips were edited

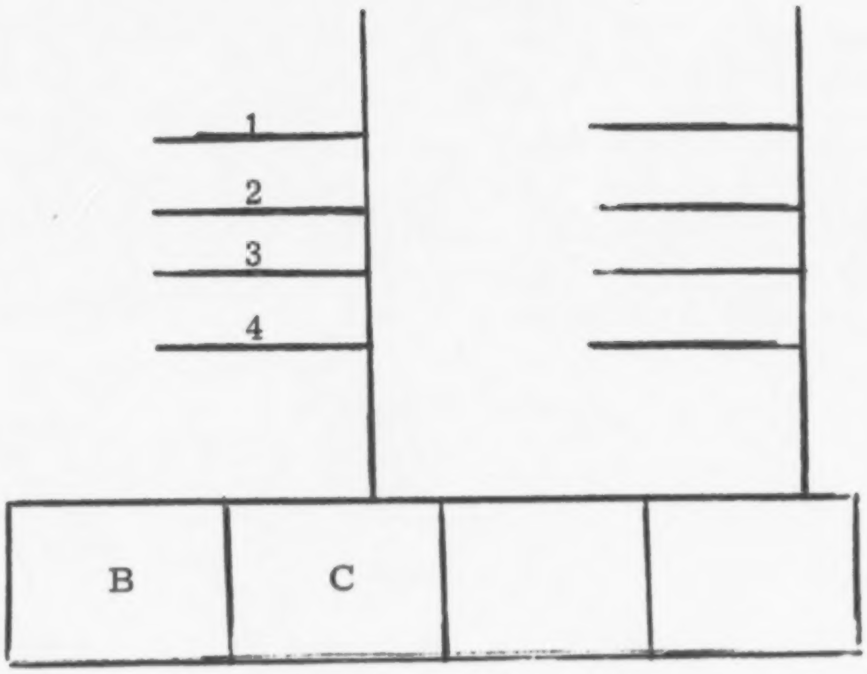


Fig. 4.12 Photographic format for the prototype of the teaching machine.

Note: The prototype was equipped with only two photo-electric cells, therefore this format has only two coding spot areas; B & C

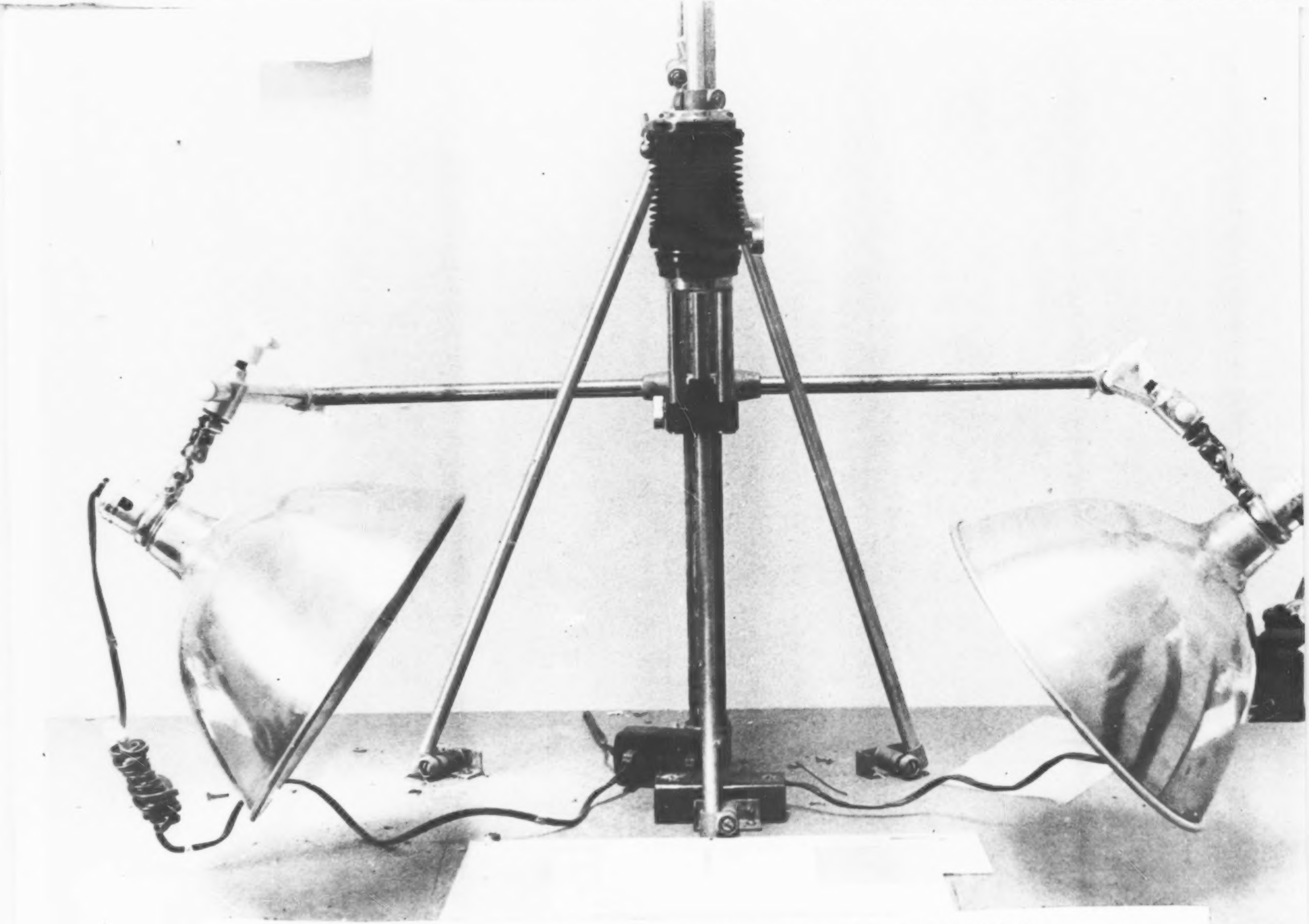


Fig. 4.13. Copying stand for small photographic format with bellows.

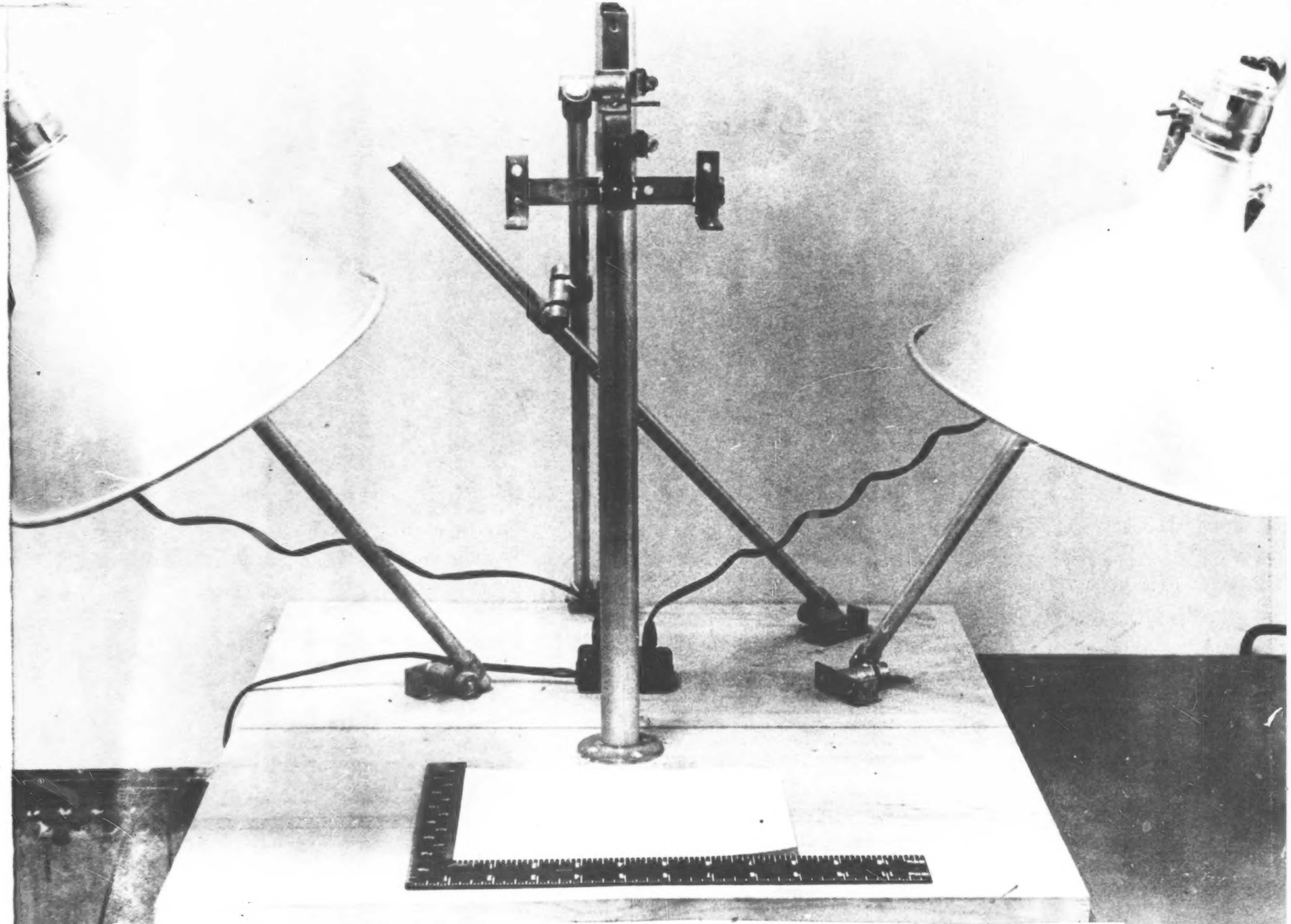


Fig. 4.14. Copying stand for large photographic format.

and errors corrected. When the strip was correct, it was spliced to a large roll of programs, and sent to DeFrenes Film Laboratories in Philadelphia, Pennsylvania to be printed on positive film. All splicing was done with a butt splicing device produced under the trade mark Quik Splice. Six positive copies of each arithmetic program and four positive copies of each reading program were made. When the positives were returned from DeFrenes, they were all on one large roll. The individual program (lesson) was then cut off the roll, rerolled and placed in a film can such at those used to package new unexposed film (see Fig.4.15). These cans were chosen for the film storage because they can be sealed simply by turning the lid tightly. Cans of this type come in a large enough assortment of colors so that each type of program could be packaged with a distinctive combination of lid and can color. For example, reading programs were placed in yellow cans with yellow lids, while arithmetic programs were in yellow cans with red lids. All master copies (negatives) were in white cans with different lid colors for each type of program.

The original (negative) film strip for each program was kept as a master copy, so that in the case of extensive film damage through use, new copies could be obtained by sending the master back to the printer.

The audio portions of the programs were read into a LaBelle Maestro II Tape Recorder (see Fig.4.16)and recorded on Scotch Brand mylar base magnetic recording tape. The Maestro II is equipped with a 1000 cycle sound generator which can place a tone on one channel of the tape whenever the operator closes a switch. This was done at the end of the audio portion of each frame. The signal is picked up by the teaching machine and turns off the tape deck. (see Technical Description).

At this point in the production, the master tape recording and a positive copy of the film strip were placed on the teaching machine and every portion of the program was checked for correctness. After any errors found were corrected, the magnetic tape was sent out to be copied. Two companies were used to do the tape copying. Recorded Publications Laboratories of Camden, New Jersey and Taben Recording Company located at Haverford College, Pennsylvania.

The pictures of objects used in the phonics programs and a few of the arithmetic programs (described elsewhere) were drawn by two local artists and then reduced in size photographically. These small pictures were then glued to the master card sets.

Only a few of the arithmetic programs used detailed pictures. For the most part, the figures used were simple outlines of a heart,

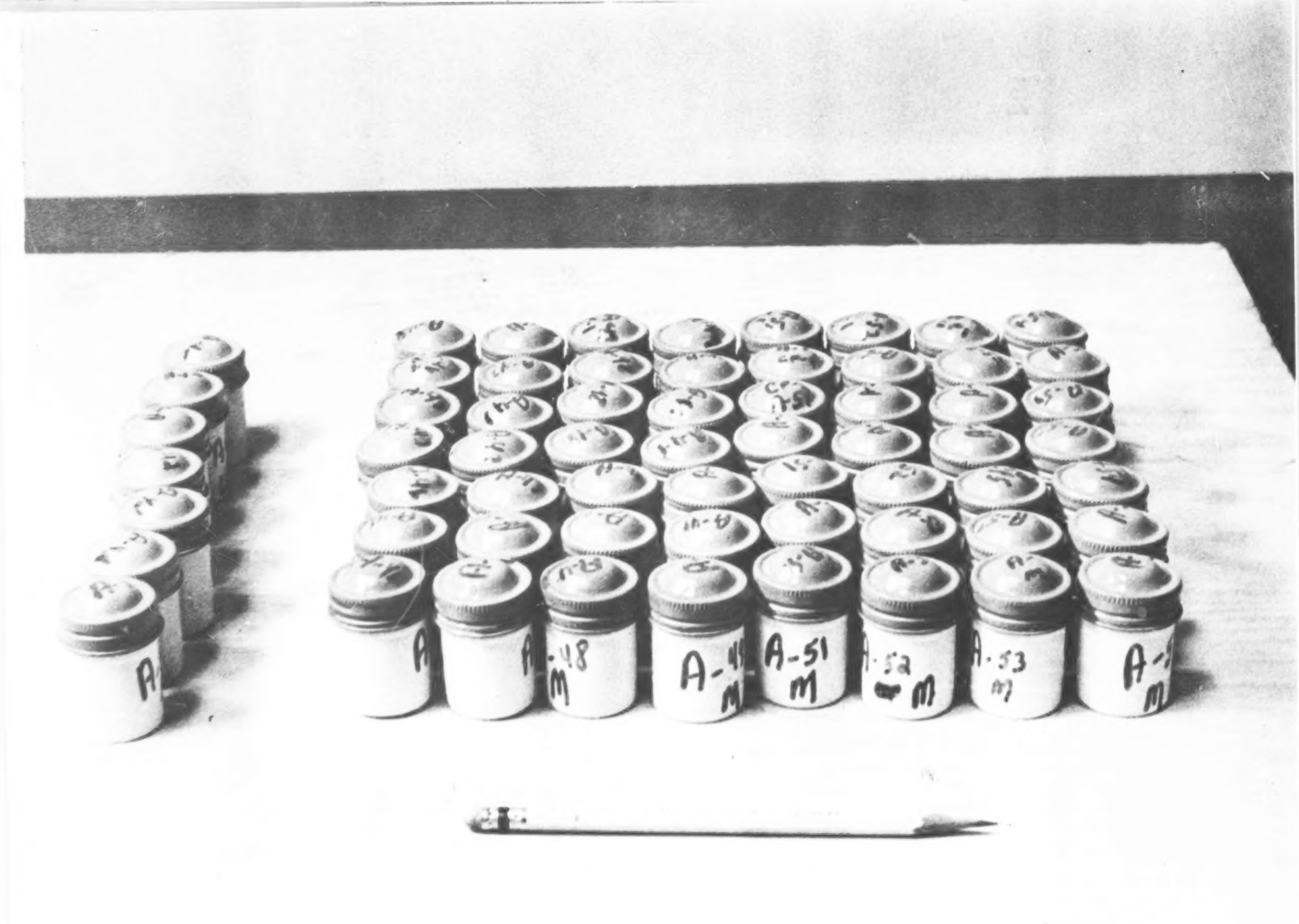

A-48
M
A-49
M
A-51
M
A-52
M
A-53
M

Fig. 4.15. Film cans used for packaging visual portion of programs.

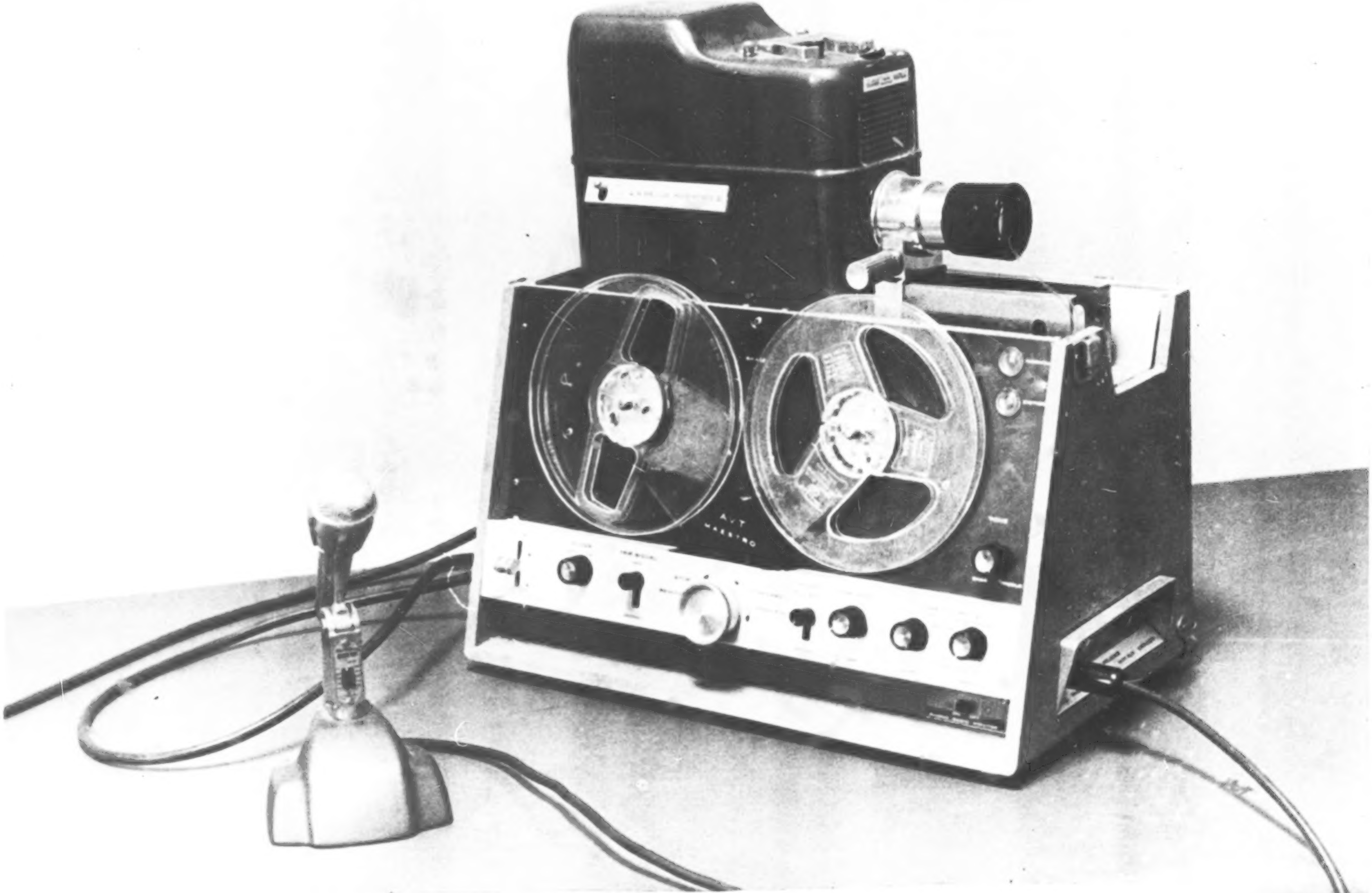


Fig. 4.16. Maestro II Tape Recorder.

mitten, star, ball, and house, which were made into rubber stamps. These stamps were then used to print the required number of figures on the master cards.

Figures 4.17 and 4.18 are excerpts from an arithmetic program. The reader will notice that on Fig. 4.17 only two of the four available choice positions are used. This is described in the section on arithmetic program writing.

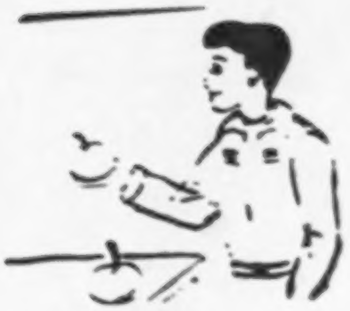
Storage of finished programs.

After the programs have been finally checked, they are stored in compartmentalized shelves in a library room, which is shown in Fig. 4.19. Figure 4.20 shows a close-up top view of one shelf containing reading programs. Access to the library room is limited and all materials must be signed for before they can be taken out of the storage area.

Records were kept of the location of programs which were checked out for classroom and demonstration use. These records included the condition of the film strips and the magnetic tape, so that damaged materials could be replaced or repaired.

Air conditioning is recommended for this room to maintain low temperature and humidity. These conditions maximize the life span of the film and magnetic tapes.

1



2

2

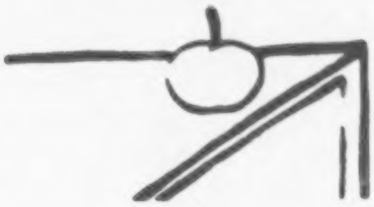


Fig. 4. 17. Excerpt from an Arithmetic Program.

1

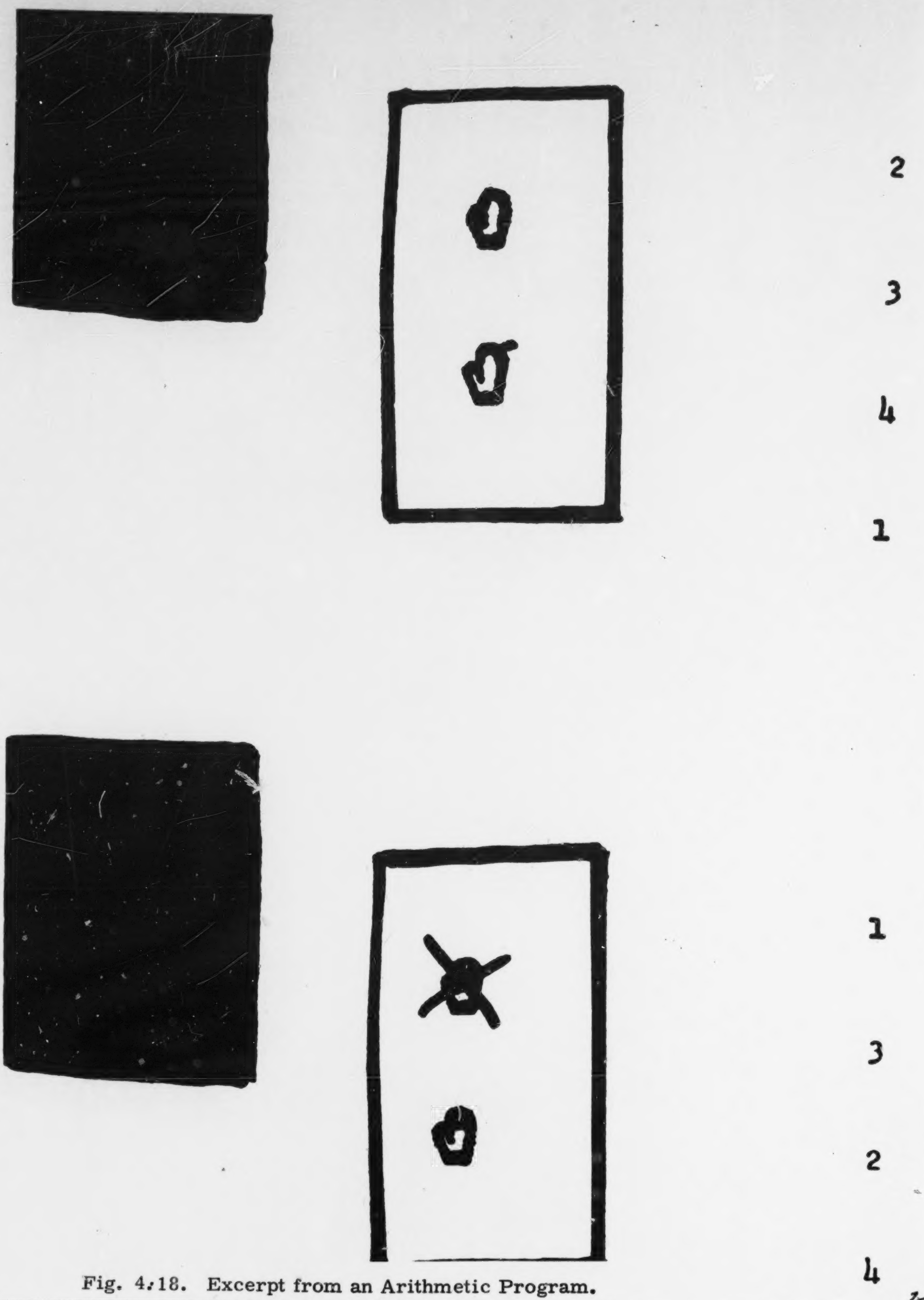


Fig. 4.18. Excerpt from an Arithmetic Program.

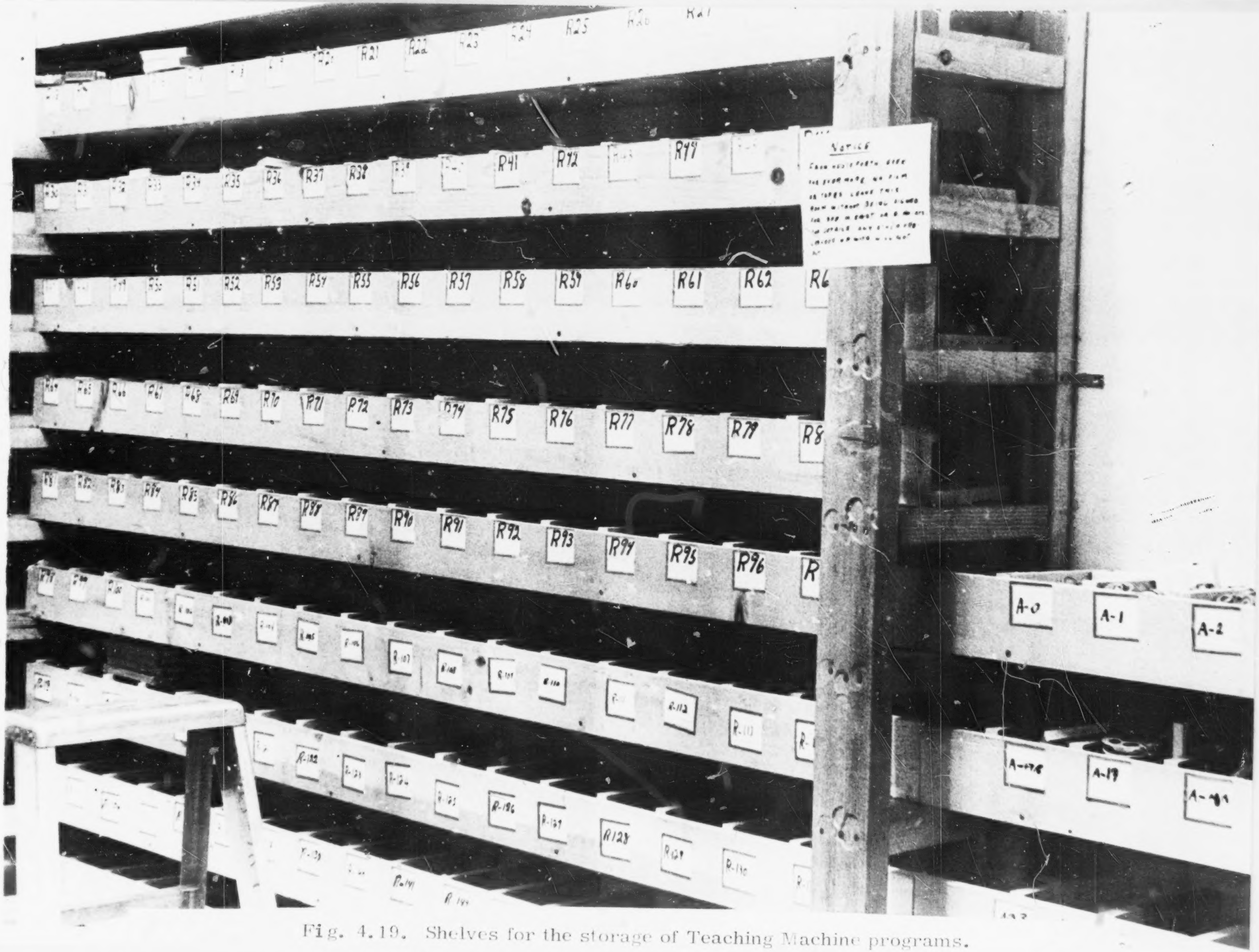

R21
R22
R25
R41
R42
R61
R62
R75
R76
R77
R78
R90
R91
R92
R93
R95
R96
A-0
A-1
A-2
A-19

Fig. 4.19. Shelves for the storage of Teaching Machine programs.

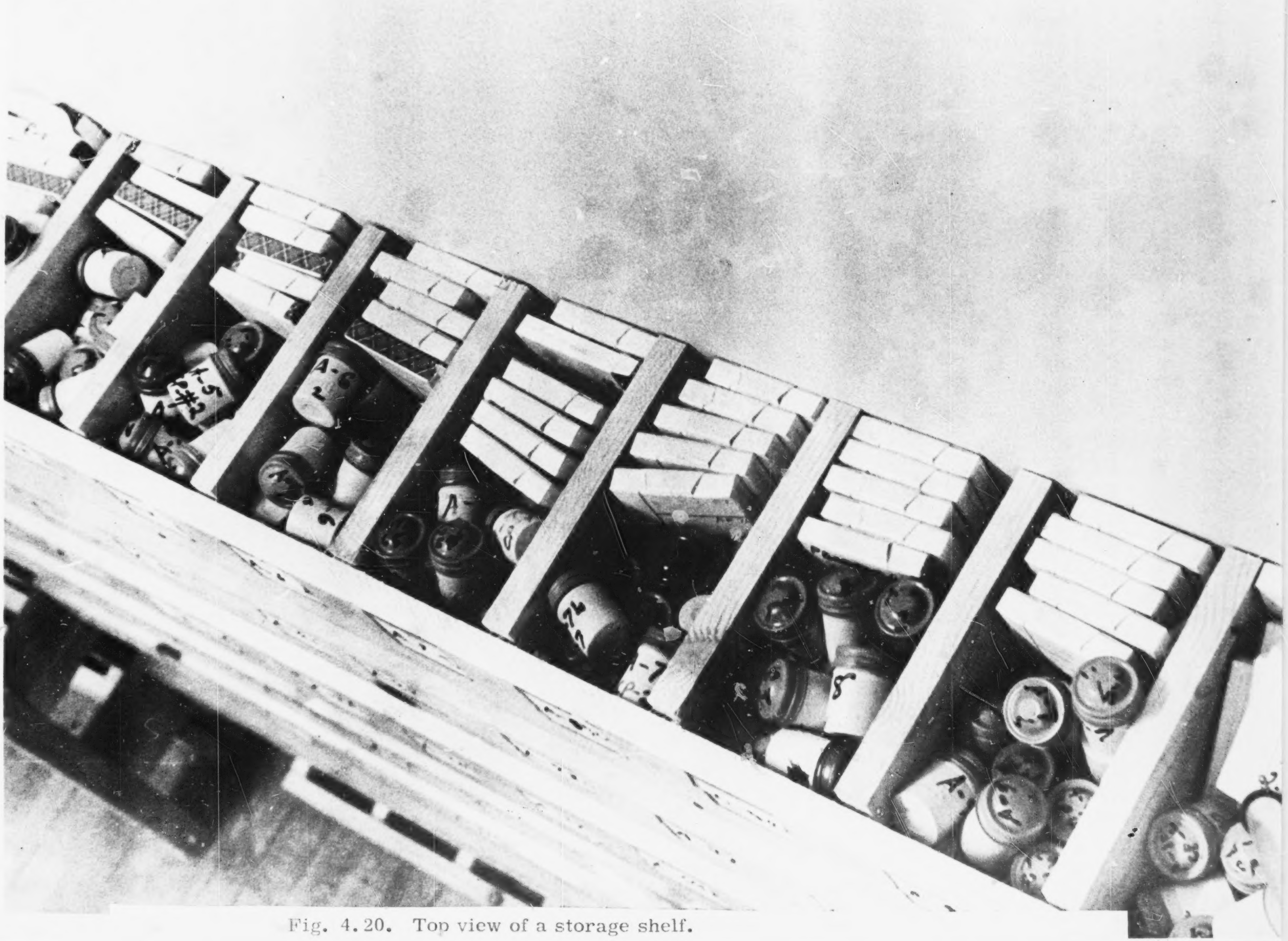


Fig. 4.20. Top view of a storage shelf.

Chapter 5

The Reading Program

James J. Forcina[1]

This chapter describes in detail the reading program for use with a teaching machine in the instruction of a selected group of mentally retarded children in residence at the Edward R. Johnstone Training and Research Center in Bordentown, New Jersey.

The task of teaching mental retardates to read is complex and arduous. As an involved verbal ability, reading is a gift of human intelligence and self-discipline. When highly developed, the ability to read appears to be an easy and near-automatic process, but actually it is the result of early learning and assimilating of many reading skills, continuous reading, and adequate intelligence. Reading skills range from the simple recognition of printed words or word parts to the more abstract comprehension and integration of meanings and ideas represented by printed words. Though reading specialists may disagree on some basic teaching approaches, they do agree on the identification of several components in the reading process. At the risk of oversimplification, the main components of this process may be broadly classified as follows: 1) word perception; 2) comprehension of meanings represented by printed words; and 3) personal integration of meanings or ideas.

Obviously, mentally retarded children, who for the purpose of this project are broadly grouped in the 50 to 75 I. Q. range, find reading a laborious, if not completely frustrating, process. They are most handicapped in their ability to deal with symbols and to comprehend abstract relationships. Depending on the degree of their retardation, it is granted that mentally retarded children with adequate adjustment, and who have received normal exposure to schooling, may learn to read some kinds of printed material. With proper teaching they may sound out words properly, attack unfamiliar words by applying rules of phonetic and structural analyses, and even read with a certain amount of fluency. The proof of the reading, of course, is neither in the skill of word calling nor in fluency; it is in comprehension. Beyond the word perception stage, mentally retarded children experience difficulty with reading at best. Generally, they lack vocabulary breadth and meaning. Putting ideas together in meaningful patterns is often difficult and they cannot easily integrate ideas in terms of their own experiential background.

In this study, the reading material programmed for self-instructional use in a teaching machine is geared to a particular group of mentally retarded children who are in the Johnstone residential school. In Chapter 7, the children for whom the program is devised are described in detail. Generally, these mentally retarded children share a similar background. Many are products of culturally impoverished home environments; many come from psychologically stricken parental backgrounds.

---

[1] Dr. Forcina is Dean of Instruction, Trenton State College.

All fall within the so-called educable classification in mental ability, IQs 50-75, and were in the age range 10 to 15 years when they started the program.

School background is particularly significant. Case histories reveal that the majority of the children involved in the program have been in and out of an abnormally high number of schools and classrooms. They have been subjected to the personalities and techniques of many teachers in the process. Except for a few who can handle primer reading material successfully, these children are non-readers. Unfortunately, the effects of exposure to the many and varied approaches and techniques in the teaching of reading appears to have toughened the shell of resistance to reading. Progress in reading has been practically nil despite the four to eight years of previous schooling and reading instruction.

Other factors may also have contributed to failure to learn to read: too early introduction to reading, the children's anticipation of failure, their negative school attitudes, their fears of rejection by classmates or of competition from them, their own frustrations, and lack of teacher understanding. It can be stated positively, however, that the children whose IQs approach 50--the lower end of the 50-75 range--hardly need another reason for their inability to read. Harris (1940) reports that children with IQs between 50 and 60 cannot progress beyond second grade work, and "many of them fail to read at all." Reading authorities are generally in agreement here and place high priority on mental ability for learning to read. Most authorities agree that a mental age of 5 to 6.5 years is needed by most children before learning to read can take place. This could mean--though not necessarily so because of other variants, perhaps physical and emotional--that a child of three years with an MA of five or six years might be ready or able to read. It could mean, too, that a child of nine years with an MA of 4.5 years (IQ 50) might not be ready to read. Particularly, he would be unable to handle abstract symbols, let alone the complex rules and generalizations of phonetic analysis. Frustration on the part of both teacher and pupil may result if the teaching attempt is made. Likewise, it may be wrong for a teacher to label a child of twelve years with an IQ of 50 as having a reading disability if he reads on a first grade level. Actually this child's reading level is about what can be expected as determined by his potential at an MA of six years. He does not have a reading disability; he is handicapped by mental and reading retardation (Hutt & Gibby, 1958; Strang et. al., 1955).

The Teaching Machine

The teaching machine and the programs developed for beginning instruction in reading are put to the test in this experimental project. The objective is to determine the success with which the special needs of the children in the sample are met by the use of a self-instructional device and the program adapted for it. In Chapter 1, the problem of the total project is explained, and the rationale behind the use of programmed instruction and self-instructional devices is discussed. Briefly, important characteristics of the teaching machine process are: 1) the active involvement of the learner, 2) the immediate reinforcement of the correct response, and 3) the ordering of learning material in optimal sequential steps, each finely graded to assist the learning of old material as movement to new takes place. The importance of the program fed into the machine cannot be overemphasized.

The programmed material and the teaching machine constitute a "last ditch" attempt to teach the children participating in this study to read. Past school history and the mental handicap itself almost compel a new approach to reading. Harris (1940) acknowledges that most mental retardates dislike reading and that motivation is an important problem in teaching them to read. As a concomitant of the mental handicap, short attention span and distractibility make reading difficult. "Extrinsic and artificial forms of stimulation must be used to a considerable extent, since these children cannot keep a remote goal strongly in mind" (Harris, 1940). Meier (1935) supports this view. It is very important, too, that mentally retarded children are aware of their slightest progress and smallest success (Strang et. al., 1955). Teaching machine programming is devised to give this kind of reinforcement immediately. It is not the purpose in this study, however, to isolate the child from the teacher. The regular classroom teacher, under whose supervision and help programmed instruction takes place, gives continuous support, encouragement, and reinforcement after each lesson has been self-taught with the use of the teaching machine.

The Reading Program

The reading course programmed for instruction in the Project contains 311 words (Appendix A). These words were intended to be learned by the children in twenty units over a period approximating one year. This number of words compares with a median number of 338 words presented in the total first-year program of twelve of the most popular basal reading series (Harris, 1962). Groff (1961) indicates that work load is an individual matter. He finds that the highest number of words presented in the first year of school by any of the popular series is 477, the lowest 235 words. Whereas, it can be expected that some of the words in the first grade vocabularies of basal readers will be new to some six or seven year olds, none of the 311 words in the present Project are new to the hearing and speaking vocabularies of the children participating in the experiment. The words were carefully chosen to reflect the functional oral vocabulary used by these children every day. Because these children are much older (median age 12.5) than normal children starting to read, and because they hear and speak these words meaningfully and frequently, it has not been considered wise to limit the selection of words to those ordinarily found in first grade lists and readers. Most of the words are derived from the lower levels of Borreca's et. al.,

(1953) vocabulary list. Several words included in the program are not found in Borreca's list, but are nonetheless commonly used by the children. It has been discovered that the usual kind of standard list contains many words which are inappropriate to the experiences of mentally deficient children and at the same time omits words important in their backgrounds.

In the entire program, only these 311 words are taught, except for three proper nouns (King, Spot, and Mary) which are used in the titles of stories and which are read to the Ss when shown. No new words are introduced by the teacher in her reinforcing activities.

Each of the twenty units introduces a number of new words. The earlier units present a greater number of new words than the later units. Enough words need to be learned in the early units to permit the learner to use them meaningfully immediately in the program. As early as Unit 1 sentences in Subunit 2 immediately follow the words in Subunit 1. Functional application is necessary to avoid boredom and loss of retention. Because of the longer list of words to be learned in the first four units, it can be expected that considerably more time will be needed to complete them than will be needed for later units. Table 5.1 shows the number of new words in each unit.

Organization of the Program:

Each of the twenty units is divided into three subunits. In the first subunit of each unit, the reading skill of sight word recognition is emphasized. In the second subunit of each unit, comprehension of word meanings is tested by using the new words in short sentences. And in the third subunit of each unit there is an emphasis on particular basic phonics, sounds which are taught largely by association with the letter symbols and by auditory support.

Each subunit is further divided into lessons, the number of lessons depending on the number of new words in Subunit 1, the number and length of the sentences in Subunit 2, and on the number of sounds taught in Subunit 3. Each lesson in turn is broken down into frames which are shown on the teaching machine screen. Table 5.2 is a schematic diagram of the parts in Unit 1. There are 10 lessons on word recognition in Subunit 1, four lessons on comprehension in Subunit 2, and four lessons on phonics (initial consonant sounds in this unit) in Subunit 3. Each lesson is recorded on one roll of film and on one associated audio tape. Each lesson is presented at one sitting at the machine and may take anywhere from 10 to 30 minutes, depending on the individual, on the number of frames in the lesson, and on the kind of thinking which must be done. For example, a frame showing four sentences which must be read before a button can be pressed in answering will take longer than a frame showing four words from which one word is to be selected as requested by the audio stimulus.

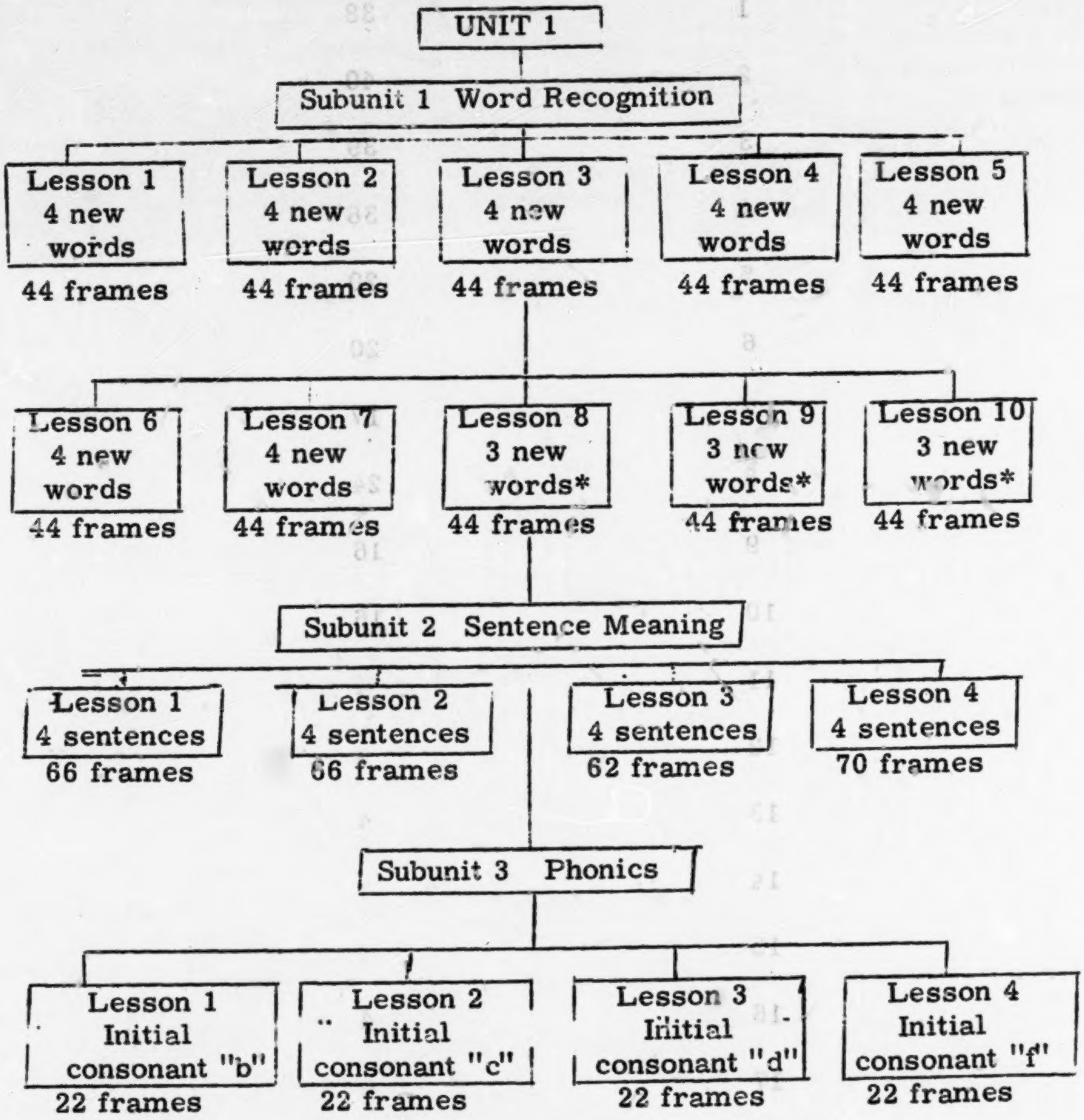
Table 5.1

Number of New Words in Each Unit

Unit	New Words
1	38
2	40
3	39
4	38
5	20
6	20
7	17
8	24
9	16
10	16
11	4
12	4
13	4
14	4
15	4
16	4
17	4
18	4
19	8
20	4
Total new words	311

Table 5.2

Unit 1 Components


UNIT 1
Subunit 1 Word Recognition
Lesson 1 4 new words
44 frames
Lesson 2 4 new words
44 frames
Lesson 3 4 new words
44 frames
Lesson 4 4 new words
44 frames
Lesson 5 4 new words
44 frames
Lesson 6 4 new words
44 frames
Lesson 7 4 new words
44 frames
Lesson 8 3 new words*
44 frames
Lesson 9 3 new words*
44 frames
Lesson 10 3 new words*
44 frames
Subunit 2 Sentence Meaning
Lesson 1 4 sentences
66 frames
Lesson 2 4 sentences
66 frames
Lesson 3 4 sentences
62 frames
Lesson 4 4 sentences
70 frames
Subunit 3 Phonics
Lesson 1 Initial consonant "b"
22 frames
Lesson 2 Initial consonant "c"
22 frames
Lesson 3 Initial consonant "d"
22 frames
Lesson 4 Initial consonant "f"
22 frames

---

*The fourth words in Lessons 7, 8, and 9 are repetitions of words taught in previous lessons.

The remaining 19 units contain the same components as Unit 1. Table 5.3 gives the breakdown of the total numbers of subunits, lessons, and frames in each unit.

Whole Word Emphasis

The first subunit in each unit concentrates on teaching new words by the whole-word, or sight, method. Though all newly introduced words are initially taught, or learned, by the whole-word method, the major basic phonetic sounds are an important part of the program and of each unit. The words selected for the program are grouped in the units according to the phonics to be emphasized in each unit. The first five of the twenty units stress initial consonant sounds (single consonants only); the next five units accentuate initial blends and digraphs, the last ten units emphasize the long and short vowel sounds. A description of the phonetic elements and their arrangement in the program are given later in this chapter.

The remaining component of the reading program is the short story, employed to test comprehension. A series of short stories, each consisting of six or seven short sentences, is presented after the last unit of each of the three groups of units emphasizing particular areas of phonics. Specifically, after the first five units, which teach initial consonant sounds, seven short stories are presented; after the next five units, which concentrate on blends and digraphs, six stories are given; and after the last ten units, seven stories. The stories are included in the program to provide interest, to check comprehension, and to reinforce retention of previously learned words. After a new word has been introduced, it will appear many times in following parts of the program.

The objective of the first subunit of each unit is whole-word recognition of new words with the auditory support. All new words--and in later units some previously taught words--are presented in groups of four, one group in each lesson of the first subunit in every unit. For example, in Unit 1, Subunit 1, there are forty words (thirty-eight new words plus two words repeated) in ten groups of four words each. Care has been exercised in the programming to avoid obvious associations among the four words in each lesson.

The word groupings of Unit 1, Subunit 1, are reproduced below in the order of their appearance in the program.

Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
ball	big	boy	birthday	fire
car	cost	cake	coat	count
dirty	dog	day	doll	dollar
fat	father	is	fun	it

Table 5.3

Numerical Components of Units

Unit	Subunit	Number of Lessons	Number of Frames	Unit	Subunit	Number of Lessons	Number of Frames
1	1	10	440	11	1	2	88
	2	4	264		2	2	104
	3	4	88		3	1	22
2	1	10	440	12	1	2	88
	2	4	238		2	2	106
	3	4	88		3	1	22
3	1	10	440	13	1	2	88
	2	4	248		2	2	100
	3	4	88		3	1	22
4	1	10	440	14	1	2	88
	2	4	238		2	2	104
	3	4	88		3	1	22
5	1	5	220	15	1	2	88
	2	3	182		2	2	100
	3	4	60		3	1	22
6	1	5	220	16	1	2	88
	2	3	188		2	2	104
	3	4	56		3	1	22
7	1	4	176	17	1	2	88
	2	3	196		2	2	102
	3	4	56		3	1	22
8	1	6	264	18	1	2	88
	2	3	182		2	2	98
	3	6	84		3	1	22
9	1	4	176	19	1	2	88
	2	3	184		2	2	98
	3	4	56		3	1	22
10	1	4	176	20	1	2	88
	2	3	188		2	2	114
	3	4	56		3	1	22

Totals: Units 20, Subunits 60, Lessons 214*, Frames 7543.**

***Includes 20 lessons on the 20 short stories not shown in the above table. The short stories are placed as follows: 7 after Unit 5, 6 after Unit 10 and 7 after Unit 20.**

****Includes 115 frames in the 20 lessons of short stories not shown in the above table.**

Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10
book	beautiful	the	red	baby
color	cat	cookies	count	has
dime	door	face	dark	cost
first	a	on	family	fireman

The initial teaching of each new word is done entirely by the whole word, or sight method. The background of the Ss indicates various attempts of phonetic methods in their reading training. Whereas the more rigid and formal phonetic treatment is supported in the teaching of slow learners (I. Q.s 75-90) by some reading authorities, opinions have been expressed by others that mental retardates (IQs 50-75) are confused by overanalysis of words. Especially is this true in the case of children in the lower limits of the retardation IQ range and with emotionally disturbed children in this range. Benefits of the phonetic approach in the teaching of mentally deficient children are doubted by Harris (1940) and Gates (1947). Harris states, "a whole-word method rather than a phonetic method should be employed in teaching word recognition to mentally retarded children." These and other specialists point out that the ability to generalize from complicated phonetic associations is beyond the retarded child. This view is contested by Hegge, Kirk and Kirk (1955) who enthusiastically advocate phonetic methods in teaching reading to the mentally retarded. This program does include the instruction in basic phonics, but only after words have been learned to reduce to a minimum the number of elements to be learned at any one time.

Each group of four words to be learned is presented in one lesson containing 44 frames. There is considerable drill and reinforcement both in the initial teaching of new words and in later word analysis and application in sentences and stories. Mental retardates and slow learners generally require more reviews, more materials, more concrete illustrations, and more and different exposures in their reading education than are required by average learners (Brueckner & Bond, 1955; Bond & Tinker, 1957). Short word-study lessons in which only four words are learned in each lesson allow more flexibility in making associations and sounding out words, and allow greater opportunity for immediate success and confidence (Strang et. al., 1955). The technique employed in the initial teaching of the whole words is described below.

Pretests have shown that Ss recognize few, if any, of the words in the unit. Using the first four words in the program (ball, car, dirty, fat), S sees the following arrangement on the teaching machine screen in the very first lesson, after having experienced preliminary samples and instructions:

car O
ball O
ball fat O
dirty O

(The O's represent the four buttons on the machine). The taped auditory instructions are:

Look at the word by itself.
Look at the four words next to the buttons.
The word on top is car.
The next word is ball.
The next word is fat.
And the word on the bottom is dirty.
Press the button next to the word ball.

For reference purposes, the frame appearing above and the accompanying auditory instructions are called the A stimulus. Of course, the Ss do not ever see or hear this or any other identification symbol used by the teachers and supervisors. If the correct button is pressed (number 2), a green light appears, the next frame is flashed on the screen and the new instructions are given. If an incorrect response is made, a red light appears and S makes a second attempt and a third, if necessary, until the correct button is found.

After each of the four words have been presented twice in this context, the first word taught, in this case "ball," is presented in like manner in three more frames. The only difference, of course, is that the position of the word "ball" and the positions of the other three words are changed after each exposure.

A modified technique is then used in a second set of auditory instructions (stimulus B). The four words appear on the screen as follows:

dirty O
car O
ball O
fat O

The instructions are as follows:

Look at the four words next to the buttons.
The word on top is dirty.
The next word is car.
The next word is ball.
And the word on the bottom is fat.
Press the button next to the word ball.

The same type of frame is shown a second time, after accurate response is made to the first, but the words appear in different positions. This exercise is more difficult in that the word in question does not appear by itself and is not read for S as in the A presentation. Again for reference purposes, the above frame arrangement and the accompanying auditory instructions shall be called the B stimulus.

A last form of presentation is given and shall be referred to as C in the sequence.

ball ○
fat ○
dirty ○
car ○

The instructions here are simply:

Press the button next to the word ball .

A second exposure of this type is made with the words shuffled in different positions. These are really test frames since no help is given.

The same procedure used in teaching the word "ball" is then used for teaching a second of the four words, then a third, and then the last. After all four words have been taught, the lesson ends with eight test frames; i.e., words randomly arranged, (C) in which each of the four words is called for recognition twice.

Table 5.4 shows the sequence of the 44 frames employed in the teaching of each group of four words in subunit 1 of every unit.

All groups of four words in each of the first subunits of the twenty units are presented and taught precisely as described above. The sequence of frames is identical, and the auditory instructions are the same except for the different words to be taught in each of the succeeding groups. All words and groupings for the twenty units are given in Appendix B.

Word Meaning

Following the learning of words by the whole word method, the newly learned words are used in short sentences. Every new word appears in at least one sentence; other words learned in the program make up the remaining words in the sentences. In Unit 1, thirty-eight new words are taught, and only these thirty-eight words are used to construct the sentences. In all of the following 19 units, the number of usable and supporting words grows progressively from unit to unit since new words are being added in every unit. However, in the sentences of any one unit the new words taught in that particular unit appear at least once each in the sentences.

Table 5.4

The Sequence for Sight Recognition of Words of the 44 Frames Employed in the Teaching of Each Group of four Words in Subunit 1 of Every Unit

A_1	A_4	C_1	C_2	C_3	C_4
A_1	A_1	A_2	A_3	A_4	C_1
A_2	A_1	A_2	A_3	A_4	C_3
A_2	A_1	A_2	A_3	A_4	C_4
A_3	B_1	B_2	B_3	B_4	C_2
A_3	B_1	B_2	B_3	B_4	C_3
A_4	C_1	C_2	C_3	C_4	C_4
					C_1
					C_2

Total 44 frames

1 the first word presented
2 the second word presented
3 the third word presented
4 the fourth word presented

A S sees the word alone and the four alternatives beside the buttons, one of which is the same word as the word by itself. He hears all five and is asked to choose the correct word.

B S sees the four alternatives next to the buttons. He hears all four words and is asked to choose the correct one.

C S sees the four alternatives and is asked to choose the spoken word.

It will be noted that sentences (Subunit 2) precede phonetic training (Subunit 3) in each unit. Words have been learned in Subunit 1 through various types of drill exercises as explained in detail above. Forty-four frames are exposed, with the associated auditory instructions and support, for each of the four-word groupings taught. To introduce more word drill immediately in the form of phonetic analysis would invite boredom. On the other hand, prompt functional application of words in short sentences might help to build confidence and give the learner a reliable medium for testing the comprehension of word meanings. For purposes of description and illustration, the first material programmed for Lesson 1, Subunit 2 in Unit 1, will be reproduced here. Sentences are grouped four to a lesson. In this lesson, the sentences follow:

The ball is big.

It is a beautiful day.

A dog is fun.

The baby has a birthday cake.

The first frame to be seen by S is a single sentence, one of the four above, next to one of the buttons (Stimulus A):

○

○

The ball is big ○

○

The oral instructions are these:

Here is a sentence made up of words you have already learned.
This sentence says, "The ball is big .
This sentence begins with a big letter that is called a capital letter.
Look at the capital letter of this sentence.
It is a capital T .
This sentence ends with a dot that is called a period.
Look at the period at the end of this sentence.
Press the button next to the sentence that says, "The ball is big ."

Though the learner has had many lessons in previous schooling on beginning a sentence with a capital letter and ending it with a period, these very basic structures are brought to the learner's attention as simply and directly as possible. Since only the one sentence appears on the screen, there is little chance for confusion or error.

The second frame shows the same sentence standing alone on the left side of the screen and four sentences, one of which is the sentence on the left, opposite the buttons. This referred to as Stimulus B.

A dog is fun. ○

The ball is big. ○

The ball is big.

It is a beautiful day. ○

The baby has a birthday cake. ○

The auditory instructions are these:

Look at the sentence by itself.
That sentence says, "The ball is big ______."
Now look at the four sentences next to the buttons.
The sentence on top says, "A dog is fun ______."
The next one says, "The ball is big ______."
The next one says, "It is a beautiful day ______."
The one on the bottom says, "The baby has a birthday cake."
Press the button next to the sentence that says, "The ball is big ."

In responding to the stimulus, the learner may utilize several supports or cues. It is most desirable if he takes his time to compare and identify the words in the sentences appearing on the screen and to listen carefully for auditory cues.

The next frame, Stimulus C, removes the sentence at the left so that no visual comparisons can be made.

It is a beautiful day. ○

A dog is fun. ○

The baby has a birthday cake. ○

The ball is big. ○

S must depend entirely on the auditory cue which is:

Look at the four sentences next to the buttons.
The one on top says, "It is a beautiful day ___."
The next one says, "A dog is fun ."
The next one says, "The baby has a birthday cake ."
The one on the bottom says, "The ball is big ."
Press the button next to the sentence that says, "The ball is big ."

It is still likely that S may recognize on the screen only one or two of the spoken words and render the correct response. In the frame which follows, (Stimulus D), all support is lifted except the one spoken sentence:

The baby has a birthday cake. ○

A dog is fun. ○

The ball is big. ○

It is a beautiful day. ○

The auditory instructions are simply:

Press the button next to the sentence that says, "The ball is big." This is truly a test situation in which S must read, or attempt to read, all four sentences on the screen and discriminate among them in his effort to match the correct sentence to that which he has heard. The element of chance is reduced, but the probability does exist that he will recognize one printed word correctly, the one which appears only in one sentence which permits him to press the right button without the benefit of reading all sentences or recognizing all the words in the correct sentence. This is not wholly undesirable, however, since rapid perception and thinking are processes essential to reading and since the two following exercises contain elements which force tighter tolerances in the discrimination process.

Stimuli E and F instruct the learner to find among four words seen on the screen the correct one which is left out of the sentence also shown on the screen. The single words are taken from those already learned in previous lessons. The difference between E and F is that in E, the complete sentence is shown on the screen as well as the incomplete sentence. In F, only the incomplete sentence is presented, as well as the four words next to the buttons:

In E, the screen shows the following frame (from Unit 1):

	dirty	○
The ball is big.	ball	○
The ___ is big.	color	○
	first	○

The instructions are:

Look at the sentence on top.
That sentence says, "The ball is big."
The sentence on the bottom is the same as the top one except that one word has been left out.
Look at the four words next to the button.

The word on top is dirty .
The next one is ball .
The next one is color .
The word on the bottom is first.
Press the button next to the word that has been left out
of the bottom sentence.

The frame in Stimulus F omits the complete sentence:

The ball __ big.

car ○
fun ○
birthday ○
is ○

The instructions for F are:

Look at the sentence that has a word left out.
Look at the four words next to the buttons.
One of these words is the word that was left out
of the sentence.
Press the button next to the word that was left
out of the sentence.

As shown in both the E and F frames, the alternative words are sufficiently different in meaning, spelling, sounding, and visual appearance to reduce interference to a minimum. The object, of course, is to facilitate accurate discrimination by removing as many blocks to his success as possible. There are no trick presentations. There is only one word of the four which fits the blank space in the sentence and makes sense. Success here means the child is reading for meaning.

The final eight frames of Subunit 2 are test frames using the D pattern again. Each frame shows the four sentences to be learned in the lesson in different positions on the screen and each accompanied by auditory instructions to "press the button next to the sentence that says, "________________________________."

The number of frames in each lesson of four sentences, recorded on one film set and on one related auditory tape, varies with the number of words in each of the four sentences. As described above, the E and F patterns instruct the learner to find among the four words shown, the one word left blank in a sentence also shown on the screen. Larger sentences will require a greater number of frames; e.g., if a sentence is made up of six words, six frames will be needed if one word is left out of the sentence each time it is shown. On the other hand, if only three words constitute a sentence, only three frames will be needed. It will be noted that the words "a", "an", "the", "it", "is", "to", "I", and "in" appear so frequently in the sentences (Subunit 2 of each unit) that they are tested in the E and F patterns only occasionally. The number of frames in these subunits vary from a low of 46 to a high of 70.

Table 5.5 shows a typical sequence pattern of a lesson in Subunit 2.

Phonics

In projecting the reading program for this experiment, decisions as to content and procedures have been reached on a realistic understanding and approach of what the participating retardates could be expected to learn. The point has already been made, that low intelligence imposes definite limitations on one's ability to read with understanding. Perception of the complexities of word analysis is also limited (Gates, 1947). In light of these limitations and other circumstances described earlier, the sight method of learning new words is the first step in each unit. Simple and basic phonetic associations are revealed to the learner after he had learned the words. No rules are taught; no difficult variations or exceptions are pointed out; no root words or other structural elements are presented.

The program of phonics in the third Subunit of each Unit gives further reinforcement of words already learned and provides additional experiences and guidance in exploring the visual and auditory characteristics of words. Only one phonetic sound is taught in each lesson. The instructions and illustrations are concrete and simple. Each sound is presented in at least four words already learned in different ways. There are no far-reaching generalizations or applications. The goals are short range, associations are made clearly with familiar words and letters. This approach is essential in teaching retardates to read (Brueckner & Bond, 1955; Gates, 1947). They would appear to require sense training, experiences at matching sounds and matching pictures and symbols (Strang et. al., 1955).

It is recalled that in the first presentation of words (Subunit 1 of each Unit). The sight, or whole-word method is used. To ensure that the learners associate both sound and meaning with each sight word, appropriate exercises are provided as discussed earlier. In each Subunit 2, the new sight words are used in sentences and become part of the reading vocabulary. With a reasonable stock of sight words available, the learner is ready to see and understand some relationships between letters and sounds in words completely familiar to him (Gray, 1960). Care is exercised in the program to avoid overanalysis of words phonetically. Only basic sounds are introduced and drilled. Except for the few vowel sounds, basic initial consonant sounds--single consonants, blends and digraphs--are presented. To

Table 5.5

Sequence for Word Meanings in Sentences

A_1	F_1	F_2	E_3	E_4	D_2
B_1	F_1	F_2	F_3	E_4	D_1
C_1	F_1	F_2	F_3	E_4	D_2
D_1	D_1	D_2	F_3	F_4	D_4
E_1	A_2	A_3	F_3	F_4	D_3
E_1	B_2	B_3	D_3	F_4	
E_1	C_2	C_3	A_4	F_4	
E_1	D_2	D_3	B_4	D_4	
E_1	E_2	E_3	C_4	D_1	
F_1	E_2	E_3	D_4	D_4	
F_1	E_2	E_3	E_4	D_3	

Total frames 60

1 = the first sentence presented
2 = the second sentence presented
3 = the third sentence presented
4 = the fourth sentence presented

A = S sees one sentence, hears it, sees and hears capital letter and period, *hears sentence again and is asked to press correct* button.

B = S sees one sentence to the left of screen and four sentences opposite buttons, hears the five sentences read, and is asked to select correct sentence.

C = S sees and hears four sentences and is asked to select the one sentence restated.

D = S sees four sentences and is asked to select the one spoken sentence.

E = S sees one sentence complete and the same sentence with a word left out, hears the complete sentence, sees and hears four words next to buttons, and is asked to select word missing from incomplet sentence.

F = S sees one incomplete sentence and four choice words, and is asked to select the word which is left out of the incomplete sentence.

attempt to teach finer discrimination, consonant sounds in other positions in words, and rules might add too many variables and complexities for this particular group of mentally-retarded children.

Word analysis beyond what is done in Subunits 1, 2, and 3 is left for the future. Those retardates who meet complete success in this program . may be exposed to more difficult types of word analyses, such as suffixes, identification of root words, and more complex phonics, in future programs.

Phonics are taught in each of the twenty units. In every unit, they appear in the third subunit, after words have been taught and read in sentences. Following are the sounds taught in each unit:

Unit 1 - initial consonants b, c, d, f,
2 - " " g, h, j, k,
3 - " " l, m, n, p,
4 - " " r, s, t, v,
5 - " " q, w, y, z,
6 - initial consonant blends br, cr, dr, fr
7 - " " " gr, pr, tr, wr
8 - " " " bl, cl, fl, gl, pl, sl
9 - " " " st, str, sp, sm
10 - initial digraphs ch, sh, th, wh
11 - long a (ā)
12 - short a (ă)
13 - long e (ē)
14 - short e (ĕ)
15 - long i (i)
16 - short i (i)
17 - long o (ō)
18 - short o (ŏ)
19 - long u (ū)
20 - short u (ŭ)

Only one sound is taught in a lesson. In Unit 1, there are four lessons in phonics, one each for the sounds of b, c, d, and f. To illustrate the procedures used for teaching the initial consonants, as well as the initial consonant blends and digraphs, the first lesson in phonics is described here.

The first frame (Stimulus A), seen on the screen in this lesson is as follows:

ball		○
big		○
	b	
boy		○
birthday		○

The auditory instructions for Stimulus A are:

Look at the four words.
Listen as I read these words. You will hear that all the words sound alike at the beginning.
Listen carefully:

ball
big
boy
birthday

Now look at the words again. Do you see how they look alike? (Pause)
Yes, they all begin with the same letter.
That letter is b.
Look at the letter b.
Press the button next to the letter b.

The main purpose of the presentation is to help S associate the letter "b" with the initial sound in familiar words beginning with "b".

The second frame represents pattern B

	c	○
b	d	○
(picture of a boy)	b	○
boy	f	○

The instructions for pattern B are:

Look at the picture of the boy.
The word under the picture is boy.
The letter over the picture is b.
Look at the four letters next to the buttons.
Press the button next to the letter that looks and sounds like the first letter in the word boy.

Here the learner is helped to match the symbol and sound further. The third frame, appearing on the screen after the correct response is made to the previous frame is pattern C.

	b	○
	d	○
(picture of a boy)	f	○
	c	○

The instructions are:

Look at the picture of the boy.
Press the button next to the letter that has the same sound as the beginning of the word boy.

Assistance in this presentation is reduced to seeing the picture, hearing the word, and seeing the four letters. No visual matching can be done. The learner must identify the letter with the same sound as that he has heard. The picture is a subtle assist.

In the fourth screen showing, pattern D, no letters or words are visible. The only auditory clue is the sounding of the four words and the letter in question. S selects the picture which begins with the sound of the letter heard. There is little chance of guessing correctly. The screen appears as follows:

picture of dollar ○
picture of cat ○
picture of boy ○
picture of fireman ○

The instructions for pattern D are:

Look at the four pictures next to the buttons.
They are pictures of a:
dollar
cat
boy
fireman

Press the button next to the picture that begins with the sound of the letter b.

The fifth and final frame, pattern E, is a real test of discrimination. The screen shows only four words opposite the buttons.

car ○
beautiful ○
dirty ○
fat ○

The auditory instructions are:

Read the four words next to the buttons.
Press the button next to the word that begins with the same sound as the beginning of the word boy.

S sees four words and hears a fifth word. He must choose the word beginning with the same sound as the initial sound of the spoken word.

The sequence of 22 frames in the above lesson (Lesson 1 of Subunit 3, Unit 1) is given below. Only one consonant is taught in each lesson. The patterns are as follows:

A - S sees and hears four words beginning with same sound (in this case, "b"). He is told all begin with the same letter (b) and hears the letter named. He is asked to point out the letter, the only one shown to him.

B - S sees the letter (b), a picture, and the word represented by the picture. He hears each and is asked to choose the correct letter of the four shown.

C - S sees a picture and four letters. He is asked to select the letter (b) which has the same sound as the beginning of the word pictured and spoken.

D - S sees four pictures and hears words they represent. He is asked to choose the picture which begins with the sound of the letter spoken (b).

E - S sees four words and hears a fifth word. He is asked to choose the word with the same beginning sound as found in the spoken word.

In Units 11 to 20, the long and short vowel sounds of a, e, i, o, and u are taught. One sound is taught in each of these last ten units. The vowel sound emphasized in each word is found medially in the single-syllable words (except for and, on, and use) and in the first syllable of two syllable words. In each unit, four new words are taught and used as well as four old words in the phonics exercises, except for Unit 19 in which all eight words with long u (ū) are new.

The principal purpose for the phonics exercises on the long and short vowel sounds is to help the learner recognize that vowels have sounds as do consonants and to differentiate between the two most frequently used sounds of each vowel. Identifying these sounds in words already known without reference to rules, exceptions, diacritical marks, rationalizations, or generalizations is less burdening and less confusing or frustrating than the instructional treatment given to these sounds in a normal program of reading and phonics.

In pattern A of each long vowel sound, the screen shows (illustrating with words and long vowel sound "ā" of Unit 11):

Table 5.6

Sequence for Phonics: Initial Consonants b, c, d, f, g, h, j, k, l, m, n, p, r, s, t, v, *

A	C	D	E
A	C	D	E
B	C	E	E
B	C	E	E
B	D	E	
B	D	E	

Total frames: 22

***Eight words beginning with each consonant are used. See Appendis B, Units 1 to 4 for words.**

Sequence for Phonics: Initial Consonants q, w, y, a; Initial Blends: br, cr, dr, fr, gr, pr, tr, wr, bl, cl, fl, gl, pl, sl, st, str, sp, sm; and Initial Digraphs ch, sh, th, wh.

A	C	D	E
A	C	D	E
B	D	E	
B	D	E	

Total frames: 14

***Four words beginning with each consonant, blend, or digraph shown are used. See Appendix B, Units 5 to 10 for words.**

baby ○
cake ○
late take ○
play ○

The instructions for pattern A are:

Look at the four words.
Do you see that all the words have the letter "a" in them?
Listen as I read these words. You will hear that the letter "a" sounds like "a" in all the words.

baby
cake
late
play

Look at the word take next to the buttons.
Did you hear the " a " sound again?
Press the button next to the word take .

In patterns B, C, and D, the presentations, both visual and auditory, are the same for the long and short vowel sounds. S sees the following in pattern B:

bed ○
cost ○
fun ○
make ○

The auditory instructions are:

Look at the four words next to the buttons.
Starting at the top, these words are

bed
cost
fun
make

Press the button next to the word that has the sound of "a" in it.

The visual presentation in pattern C is:

picture of book ○

picture of key ○

picture of cake ○

picture of monkey ○

The instructions:

> **Look at the four pictures next to the buttons.**
> **They are pictures of book**
> **key**
> **cake**
> **monkey**
>
> **Press the button next to the picture of the word that has the sound of "a" in it.**

Pattern D shows four words on the screen:

doll ○

paper ○

visitor ○

school ○

The auditory instructions are:

> **Read the four words next to the buttons.**
> **Press the button next to the word that has the sound of " a " in it.**

In pattern B, C, and D, S is asked to select the word with the sound of long a. In no case is the word "long" mentioned; only the long a ($\bar{a}$) sound is spoken. For those children who master the entire program, a follow-up reading programm with more specifics is a possibility. In the current program, the goal is to help the learner become aware of some basic sounds in common words and to hope that some association will be drawn between sound and symbol.

Sequence for Phonics: Long and Short Sounds of
a, e, i, o, and u

A	B	C	D
A	B	C	D
B	B	D	D
B	B	D	D
B	C	D	
B	C	D	

Total frames: 22

Stories

Three groups of stories are included in the reading program. Their purpose is to test S's ability to read words and sentences which together tell something--the ability to comprehend written material. The words in each story have been learned in lessons prior to the presentation of the story. The ideas which the words and sentences convey are well within the experiential background of the child. There are from four to seven short, simple sentences in each story. It is hoped the child gains confidence in his ability to actually read something for real comprehension.

Seven short stories are presented after Unit 5, using words learned in the first units (initial consonants). Seven more short stories appear after Unit 10, using words learned in the first ten units (initial consonants, blends, and digraphs). Six short stories are given after the twentieth and last unit, using words learned in all twenty units (initial consonants, blends, and digraphs, and long and short vowels). The great majority of words taught and drilled in the three subunits of those units already covered are used in the stories and in the other visual presentations in relation to the stories. After each story, three to five questions are asked, in answer to which S chooses one of four alternatives and in a few cases one of two alternatives.

The first story and auditory questions after Unit 5 are given below, illustrative of all other lessons on stories. The story appears first on the screen.

King

I have a dog.

King is his name.

He is a police dog.

Father gave it to me.

My dog is very big.

He is beautiful.

He is kind.

The auditory instructions are:

> The name of this story is King. It is a story about a police dog. Read it carefully to yourself. Press the top button when you have finished reading.
>
> (Pause of two minutes)
> The story reappears after button is pressed. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.

This is the only time that the classroom teacher must be present to hear the child read the story aloud. It is a test to find out if he can really read the words and sentences. If he cannot read them, he is not yet ready for the stories. If he meets complete success or very nearly complete success in the oral reading, he is permitted to go on and the instructions continue:

> Press the top button when you have finished reading.

These words appear next:

King ○
boy ○
judge ○
lion ○

The instruction are, "What is the dog's name?"

The next frame shows:

a mother dog ○
a little dog ○
a police dog ○
a small dog ○

And the instructions are, "What kind of a dog is he?"

After the correct button is pushed, the next frame shows:

sister ○
teacher ○
mother ○
father ○

The instructions are "who gave me the dog?" The last frame shows:

dark ○
beautiful ○
little ○
fat ○

The instructions are, "How does my dog look?"

Teacher supervision during the story exercises is essential for this part of the program is the ultimate test of actual reading. If it is found that a S presses two or more buttons rather consistently before getting the right answer, it can be concluded that he is either completely inattentive or that he has not learned to assimilate or find meanings in the printed words. If the latter is true, S may have to be drilled on earlier lessons again.

Conclusion

The reading process is complex. It is very difficult for mentally retarded children. Reading skills number in the hundreds in most programs of reading instruction. To attempt to teach many reading skills, such as the intracacies of phonetic and structural analyses of words, would confuse and frustrate the retardate whose I.Q. ranges from 50 to 75, and especially the older, "hard-core" retardate (ages 10-15) who has not learned to read despite years of reading instruction. Consequently, a very simple and basic program of reading instruction has been constructed to meet the special needs of the particular retardates to be taught. The material--words, sentences, phonics, and short stories--is programmed for teaching in a teaching machine, but teacher supervision and reinforcement are also required. The program is aimed at giving the mental retardate reasonable success and confidence in reading words and ideas with his auditory and experience background. It proposes to cast some light on the question, "Will a carefully programmed course of reading instruction taught via a self-instructional device, but with teacher supervision and reinforcement, help non-reading mental retardates (IQs 50 to 75), 10 to 15 years of age, learn to read?"

Chapter 6

The Arithmetic Program*

Content and method are the two essential features of any instructional program. An explanation of the rationale behind these two features of the programmed sequence in arithmetic should place the detailed description of the programs in their proper perspective.

The content of the programmed materials in arithmetic is based on an adaptation of the traditional sequence for teaching elementary arithmetic concepts and skills. The major objective of the programs is to teach the concepts and processes of addition, subtraction, multiplication and division. Fulfilling this objective was the critical factor in determining which items to select and omit from the traditional curricular sequence which is much broader in scope than the one presented here.

Specific instruction in such arithmetic concepts as relative size, position and location and relative quantity were omitted. No instruction was provided in the concept of ordinal numbers nor was an attempt made to develop an adequate arithmetic vocabulary. Also missing are instructional programs in money, measurement and time. Two items which are vital to fulfilling the objective were omitted for technical reasons. The first, reproducing numbers, was physically impossible with the device employed in this study. The second, solving written problems involving the four computational processes, was eliminated due to uncertainties over the student's reading vocabularies. The "machine" could have read the problems but this would have involved a form of memory which was also an uncertain commodity.

Methodological considerations were based on the physical characteristics of the machine and the knowledge the programmer possessed of the learning characteristics of mentally retarded individuals and, specifically, their characteristic performance in arithmetic. The physical characteristics of the machine have been carefully documented elsewhere but a cursory statement of the relevant characteristics of the S̲s may explain many of the methodological techniques. Most of these characteristics have been established by research and many of them were apparent in the programmer's classroom experience with mentally retarded children.

It is consistently believed, for example, that mentally retarded individuals forget easily and require a great deal more repetition that would normally be expected. It is also expected that they will demonstrate a tendency to perform better on concrete learning tasks than those involving abstractions and that they possess limited ability to reason and generalize and consequently, to solve problems. All of these characteristics have direct relevance to their performance in arithmetic.

---

*Margaret Jo Shepherd

Since they can manage the concrete,manipulative aspects of arithmetic, they can be taught to count and master the rudiments of arithmetic computation. It does not follow, however, that they will develop an understanding of the concepts involved commensurate with their mechanical skill. It has been demonstrated that their knowledge of words utilized in arithmetic well be limited, that they will have difficulty differentiating extraneous material from needed fact, that they possess little understanding of concepts of sequence or time, that they are careless and make technical errors and that they require a great deal of emphasis on readiness skills. Of all the computational skills, addition appears to be the easiest and division the most difficult. Fractions also represent a difficult set of concepts for retarded children to grasp. Finally, it would not be uncommon to encounter perceptual disturbances.

The most comprehensive way to examine the methodology involved in this teaching sequence is to read the frame descriptions in the final section of this chapter. Every attempt was made to compensate for memory problems by providing as many associations which should have meaning for the student to each new concept and fact as possible. An effort was made to make explicit the relationships and associations between new concepts and facts and those previously taught. In many instances, review frames on important aspects of previous programs were included at the beginning of new programs. Some important items in the series were reviewed in total programs.

Every effort was made to keep both the visual and auditory presentation as simple and direct as possible. A great deal of control was exercised over the teaching vocabulary. A concerted attempt was made to emphasize the conceptual aspects of the arithmetic processes rather than strict drill on the basic facts. Each program culminated in a series of frames which were essentially drill so that the relative effectiveness of any other technique is difficult to assess.

This series of programs, as it now stands, is presented with several reservations. The foremost of these is that none of the programs were tested during their development. This means that at no time during the development of any of the programs did the programmer have any awareness of the weaknesses or strengths of the programs or of the general effectiveness of the method of programming. It is quite likely that more favorable results could have been obtained with the programs if they had been tested and revised before being used.

The second major reservation is the possibility that an effort was made to teach concepts on this machine which were not really suited to this particular method of instruction. Competence in arithmetic is dependent upon many skills which are essentially manipulative. The manipulation involves concrete objects, semiconcrete representations and finally symbols. The structure of this machine demands that these operations be conducted for the learner rather than by him. The learner has little or no opportunity to explore and discover for himself the relationships between the various elements of a numerical concept. Whether or not this could be done effectively with this machine is, at present, a matter of conjecture. The essential point for this discussion is that it is not a part of these programs.

The inability to teach anything which requires a written response was another restriction which possibly hampers the effectiveness of these programs. The fact that the machine is not the sole method of instruction does not reduce the sterility of a program which is teaching something via one response mode which will be utilized in another.

It is obvious that the verbal instructions in most of these programs are probably far too rigid and stereotyped to be maximally effective. It may have been better to establish the teaching sequence, outline it, draw up the visual portions and then ad lib the auditory presentation from the outline.

There is another aspect of rigidity in the total sequence which may reduce its effectiveness. Learning arithmetic concepts and skills is a developmental process which seems to proceed in a linear fashion. New skills and concepts are based on previous learning. The programs in this series often seem to represent sets of discrete lessons with at best rather faultly articulation between the units. This is certainly not an inevitable problem but rather one which should yield to increased skill, experience, and knowledge of programming techniques.

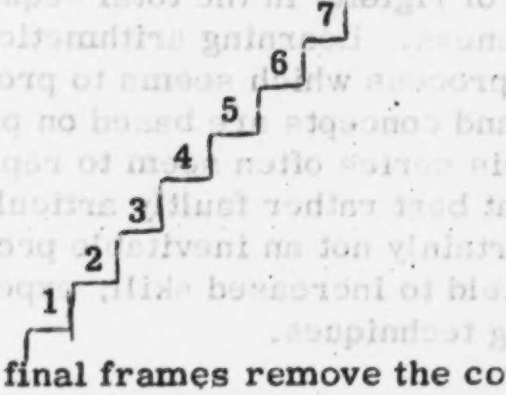
More programming time and effort should have been spent on the early sections of the series. Quantitative concepts and counting sequences, particularly, should have been presented in many and diverse ways rather than in single programs. These concepts are essential to the ability to conceptualize about the computational processes and it is probable that they did not receive sufficient attention.

With the major reservations about the programs made explicit, they are presented in detail in the following sections. First, an overview of the total sequence is presented and then a frame by frame description of the major types of programs.

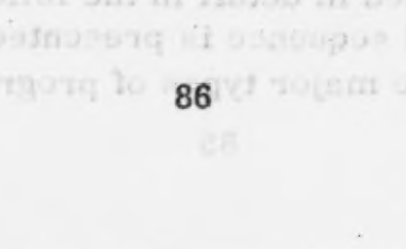
The initial program in the arithmetic sequence (No. A-O) was designed to teach form discrimination. This program teaches recognition of four basic shapes: circle, square, triangle and rectangle. It was designed with a two fold purpose: to acquaint the students with the general form the arithmetic programs would take and to establish a technique for "cueing" subsequent programs. An example of the second function of this program is contained in these statements, "you can see many numbers on the screen in front of you. Look carefully at the one number inside the circle."

The next three programs (A 1-3) were designed to teach recognition of the numbers 1 thru 10. These programs follow the method used in the word recognition programs. The student is required to select, from a list of alternatives, the correct response which has been established by a series of gradually diminishing cues until he is finally instructed to look at the four numbers on the screen and press the button next to a specific number.

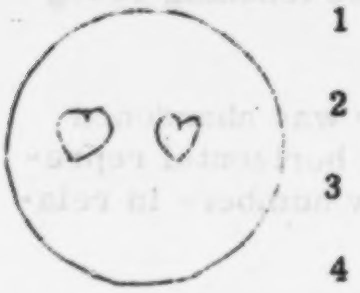
Exercises in rote counting constitute the next step of the program. Three programs (A 4-6) were written to teach the rote sequence of the numbers 1 thru 10. A prototype of a set of stairs is presented on the screen and the student is informed that he is going to place a number on each step. He is told that when he has climbed to the top he will have learned to count to ten.

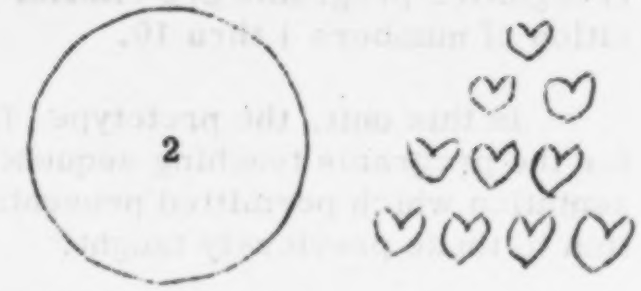


The final frames remove the counting exercise from this form and ask the student to fill in the missing number of a sequence contained in a box on the screen.



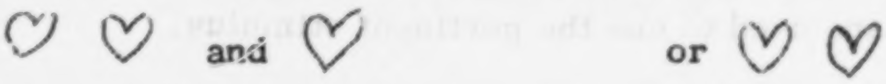
Rational counting, the ability to enumerate a group of objects correctly, is established in the next three programs (A 7-9). The student, drawing on previous learning, is required to count a series of objects and match a specific quantity to the appropriate number symbol. Two types of response are required.

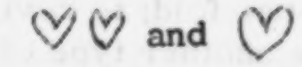




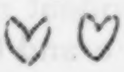
These skills constitute the background material essential to an understanding of addition (A 10-32) and subtraction (A 33-54). The forty-five addition facts presented have sums no greater than ten. The minuends in the forty-five subtraction problems do not exceed ten.

Both series of programs illustrate an attempt to teach the process of addition and subtraction rather than rote memorization of the algorisms. The student participates in the manipulation and reorganization of quantities; and is taught the symbolic representation of this manipulation and finally sees only the algorism





2 + 1 = or



3-1 =

and is required to make the appropriate response. Zero as a

$\begin{array}{r}2\\+1\\\hline\end{array}$ $\begin{array}{r}3\\-1\\\hline\end{array}$

numerical concept requires separate treatment, therefore, the pertinent information about zero and its computational use in addition and subtraction is presented in a discrete unit. The programs in the unit include recognition of zero as a number symbol (A 55), understanding the quantitative meaning of zero (A 57), placing zero in the number sequence (A 56) and addition and subtraction with zero (A 58-81). The basic form of these programs is similar to the programs dealing with numbers one through ten.

The eighth unit in the series (A 82-100) teaches number recognition and number sequence through 50. Each unit of ten numbers is divided into three programs teaching number recognition followed by two programs teaching the sequence of the ten numbers. The division is the same for each unit of ten numbers (i.e., 11 thru 14, 15 thru 17, 18 thru 20, 21 thru 24, etc.). The number recognition programs are similar in form to those teaching recognition of numbers 1 thru 10.

In this unit, the prototype of a set of stairs was abandoned for the programs teaching sequence in favor of a horizontal representation which permitted presentation of the new numbers in relation to those previously taught.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

The original presentation of the numbers 11, 21, 31 and 41 placed them adjacent to 10, 20, 30, & 40 to demonstrate continuity

1	2	3	4	5	6	7	8	9	10	11

and arrows are used to cue the pertinent stimulus.

Programs A 98 thru A 100 were designed to present the position of numbers 1 thru 50 in a different frame of reference. The purpose of these programs was two fold; to review and reinforce previous learning and to provide another type of association between the numbers and their position in the counting sequence. These programs attempted to make the student aware of the repetition of numbers 1 thru 9 in each sequence and to use this knowledge as an aid to remembering the sequence of the numbers 1 thru 50.

The next major step in the series involves teaching multiplication and partitive division. Several programs provide the foundation for the processes which are taught in the formal multiplication and division programs. Two programs (A 118-119) describe the process of column addition with 2's, 3's, 4's and 5's. These programs were included to provide a referent for teaching multiplication in relation to addition. The same rationale dictated the inclusion of programs (A 120, 121 and 122) devoted to teaching counting by 2's and 5's.

The majority of the programs in Unit 9 (A 102-117) illustrate an attempt to teach an understanding of the processes involved in multiplying and dividing. The student is presented a group of objects and then instructed to tell how many objects are contained in the total group. The large unit is divided into smaller units and the student is questioned in relation to how many objects are contained in each unit, whether or not the units are equal, how many units comprise the total group, and how many objects comprise the total when the units are combined.

One program in Unit 11 (A 127) reviews this process with emphasis placed on the process of partitive division. The question which receives priority is "If eight cookies are divided into two equal groups, how many cookies will be contained in each group?"

Recognition of the signs for multiplication and division is taught in two programs (A 122 and 126, respectively). Multiplication and partitive division by 2's are taught separately in Units 10 and 12. In the multiplication programs (A 123-125) the operation which was taught earlier is related to the algorism and the relationship between addition and multiplication is established. The commutative law in multiplication is also taught as most commonly stated, the order of multiplication does not effect the answer.

Measurement division which poses the question, "how many 2's are contained in 8" was not taught in this series of programs. The exclusion was an arbitrary one based on a belief that the distinction between the two types of division was not of sufficient importance to the student to merit the risk of confusing the presentation. Partitive division by 2's is taught in three programs (A 128-130). The programs for multiplication and division involving the two facts are written so that they can be taught together or separately at the discretion of the instructor.

Unit 13 (A 131-150) contains the multiplication and division facts for 3 and 4. The form of the division programs is the same as with 2. The multiplication programs change, however, and place less emphasis on the underlying operation and commutative law and more emphasis on mastery of the algorism. The sequence alternates between multiplication and division:

$$\text{A 131}\qquad \begin{array}{r}1\\ \text{x}\,3\\ \hline\end{array}\qquad \begin{array}{r}2\\ \text{x}3\\ \hline\end{array}\qquad \begin{array}{r}3\\ \text{x}1\\ \hline\end{array}\qquad \begin{array}{r}3\\ \text{x}2\\ \hline\end{array}$$

$$\text{A 132}\qquad 1\overline{)3}\qquad 3\overline{)3}\qquad 2\overline{)6}\qquad 3\overline{)6}$$

The five facts (A 153-160) revert to the original multiplication form to review and reinforce the concept. The division format does not change. Again the multiplication and division programs are alternated.

An attempt is made in Unit 15 to demonstrate the four processes in relation to each other and to reiterate and reinforce the relationships which do exist. Initially, the four signs are reviewed (A 161). Then a group of four objects and its various subgroups is manipulated in a manner representing addition, subtraction, multiplication and division (A 162). The same program is repeated with a group of six objects. The next eight programs (A 164-171) follow the same basic style except that the algorisms are included:

$$\text{A 164} \qquad \begin{array}{r} 2 \\ \underline{+2} \end{array} \qquad \begin{array}{r} 4 \\ \underline{-2} \end{array} \qquad \begin{array}{r} 2 \\ \underline{\times 2} \end{array} \qquad 2\overline{)\,4}$$

The final unit in the series teaches three fractions, 1/2, 1/4, and 1/3. (A 172-174). A whole quantity is represented and then divided into fractional parts, the symbolic representation of the fraction is divided and the remainder of each program is devoted to relating the symbol to the representative quantity. The last program (A 175) is a quantitative comparison of the fractions which were taught.

There are actually 202 programs in the total sequence. Several programs contain more than one part. The following sections contain an explicit description of each of the major program types.

Number Recognition

Six different types of frames were developed to teach recognition of numbers one through ten. A description of each type follows:

Type A

The number to be learned stands by itself on the left on the screen. Four alternatives, including the number which is being taught are enclosed in arrows next to the buttons. The student's attention is directed to the number on the left of the screen and that number is read to him. The four alternatives are read in the order in which they appear and the student's attention is redirected to the number on the left and it is again read to him. He is then requested to respond by selecting the alternative which matches the number on the left.

Type B

The visual display is identical to Type A. The student's attention is directed to the number on the left which is read to him. The alternatives are read and he is requested to press the button next to the specific number which is being taught (i.e., Press the button next to the number 1).

Type C

The visual display remains the same in this frame. The student's attention is directed towards the number on the left which is read to him. He is directed to examine the alternatives which are not read and to press the button next to the specific number which is being taught.

Type D

In this frame the number on the left is deleted so that the student sees only the four alternatives next to the buttons. The alternatives are read to him and he is told to press the button next to the number which is being taught.

Type E

This frame is identical visually to frame Type D. The audio portion differs in that the alternatives are not read to the student. He is instructed to look at each number carefully, to read each number to himself and to press the button next to the correct number.

Type F

Again the visual portion is identical to the two previous frames. No instructions are given to the student, however, except to press the button next to the correct number. This frame is the test frame.

The sequence for a typical program in this series would be:

				Test
1. A*$_1$	7. A$_2$	13. A$_3$	19. A$_4$	25. F$_3$
2. B$_1$	8. B$_2$	14. B$_3$	20. B$_4$	26. F$_4$
3. C$_1$	9. C$_2$	15. C$_3$	21. C$_4$	27. F$_4$
4. D$_1$	10. D$_2$	16. D$_3$	22. D$_4$	28. F$_1$
5. E$_1$	11. E$_2$	17. E$_3$	23. E$_4$	29. F$_2$
6. F$_1$	12. F$_2$	18. F$_3$	24. F$_4$	30. F$_3$
				31. F$_1$
				32. F$_2$

*A$_1$ indicates an A Type frame teaching the number 1.

The programs designed to teach the recognition of numbers eleven through fifty contain some variations on this basic pattern. Nine different frame types were developed as follows:

Type A

The last number which the student learned is displayed in a circle on the left of the screen. Four alternatives, including the number in the circle, are shown next to the button. The student is told that he has learned to recognize the numbers from zero through the number which he sees in the circle. He is instructed to look at that number, to say it to himself, to find that same number next to the buttons and press the button next to it.

Type B

The next number in the sequence is placed in the circle in this frame. Four alternatives, including that number, are placed next to the buttons. The student is told that he is going to learn a new number which comes immediately after the one he has just learned in the counting sequence. He is told to look at the number in the circle which is read to him. He is then told to say the number himself and to press the button next to the number which is the same as the number in the circle.

Type C

In this frame, the visual display remains the same as in frames A and B. The number in the circle is read and the student is directed to examine it carefully and say it aloud. He is then directed to press the button next to that specific number (Press the button next to number 11).

Type D

The visual display is identical to the previous frames. The audio repeats the name of the number and directs the student to select it from the list of alternatives.

Type E

No changes are made in this frame in the visual presentation. The student is told to examine the alternatives carefully and to select the correct one. He is reminded that he has a cue on the screen if he needs it.

Type F

This frame represents an attempt at a different type of reinforcement. The number being taught is still contained in a circle on the left of the screen. Three of the four alternatives, however are identical to the number in the circle; only one is different. The student is instructed to select the alternative which is not the number being taught and press the button next to it.

Type G

This frame is identical in both visual and auditory presentation to frame Type E except that the student's attention is not directed to the cue on the screen.

Type H

Only the alternatives are present in this frame. The student is instructed to look at each one carefully, to think about what he has been learning and to press the button next to the correct alternative.

Type I

This frame is the test frame. The student is told to press the button next to a specific number.

A typical sequence in this series would be as follows:

1. A_{11}
2. B_{11}
3. C_{11}
4. D_{11}
5. E_{11}
6. F_{11}
7. G_{11}
8. H_{11}
9. I_{11}
10. A_{12}
11. B_{12}
12. C_{12}
13. D_{12}
14. E_{12}
15. F_{12}
16. G_{12}
17. H_{12}
18. I_{12}
19. A_{13}
20. B_{13}
21. C_{13}
22. D_{13}
23. E_{13}
24. F_{13}
25. G_{13}
26. H_{13}
27. I_{13}

Test

28. I_{12}
29. I_{11}
30. I_{12}
31. I_{13}
32. I_{13}
33. I_{11}

Rote Counting

Two different formats were used to teach rote counting or number sequence. The numbers zero through ten were taught utilizing a prototype of a set of ten stairs which the student was instructed to "Climb" and to count each step as he "Climbed." Seven distinct frame types were developed:

Type A

A set of stairs and a single alternative appear on the screen. The student is told to examine the stairs and that he is going to climb them with numbers. He is told what number belongs on the first step in the series and to find that number (the only alternative) and press the button next to it.

Type B

The stairs appear with the student's previous selections on the appropriate steps. Those numbers are read and the student is told the number which belongs on the next step and to find it (again the only alternative) and press the button next to it.

Type C

A set of stairs with all the numbers in the particular sequence placed appropriately appears on the screen. A new set appears below the one already numbered. The student is told that he is to start again. He is told what number belongs on each step, the sequence appears and is read to him each time and he must select from among four alternatives.

Type D

The visual portion of the frame resembles Type C. The student is told that he will start counting again on the new steps. This time he is not told what number belongs on each step, he is told the previous number and has the numbered steps above as a cue. He must select from four possible alternatives.

Type E

In this frame the set of numbered stairs is absent. The student is told to select the number which belongs on the initial step and then the sequence is repeated up to the point where he must make a choice from among four alternatives.

Type F

A rectangle appears and the series of numbers is presented in a horizontal line. One number is missing and this space contains a short line. The numbers are read and the student is told that the line designates the missing number. He must supply this number.

Type G

This frame is the test frame. Visually, it is like frame Type F. However the numbers in the rectangle are not read to the student. He must supply the missing number without any cues.

There are three of these programs. The position of each number is always taught in relation to the previous numbers in the sequence. The student is always confronted with the entire sequence up to the position which is being taught. Zero is later taught as occupying the position at the bottom of the first step.

The teaching sequence for a typical program is as follows:

1. A_1
2. B_2
3. B_3
4. B_4
5. C_1
6. C_2
7. C_3
8. C_4
9. D_1
10. D_2
11. D_3
12. D_4
13. E_1
14. E_2
15. E_3
16. E_4
17. F_1
18. F_2
19. F_3
20. F_4
21. G_1
22. G_2
23. G_3
24. G_4

Test

25. G_2
26. G_1
27. G_4
28. G_3
29. G_4
30. G_1
31. G_3
32. G_2

The rote counting programs for the numbers 11 through 50 change in format. There are two programs for each sequence of ten numbers and the division is between 5 and 6 (11-15; 16-20). The rote counting programs are placed immediately after the programs which teach the recognition of the same ten numbers. The frame types for the first program in each sequence are as follows.

Type A

All the numbers which the student has learned up to this point appear in a horizontal sequence in decades on the screen.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30

He is told that he knows all those numbers in order and that he can count them. The numbers are counted aloud and then he is told to press the button and play the "missing numbers" game.

Type B

One box in that sequence is empty and a small arrow points to that box. The student is told to decide what number belongs in that box and to press the button next to it.

Type C

An empty box and an arrow appears at the end of the last line of numbers which the student learned. He is told that he is going to learn what number comes next (for example, what number comes after 20). Then he is told that one comes after zero; eleven comes after ten, etc. and is asked to guess what number comes after 20. The answer is then given to him and he is told to press the button next to that number which, on this frame, is the only alternative.

Type D

The student still sees all the numbers which he has learned up to this point. The empty box is now filled with the new number and the arrow is still present. He has four alternatives to select from this time.

The whole last line of numbers is counted for him through the one he is being taught (21--------31). He is asked what number comes after the one previous to the one he is being taught (what number comes after 30?). He is then told the answer and to press the button next to the number which comes after the specific number previous to the one he is being taught (Press the button next to the number which comes after 30).

Type D

The box is empty again but the arrow is still present. The student is told to count with the teacher the last line of numbers through the new number. He is then asked what number comes after a specific number, to find it and press the button next to it.

Type E

The frame looks like the previous one. The student is told the answer to the question on the previous frame and the line of numbers is counted. He is then asked the same question as before.

Type F

This frame looks like the two previous frames. The student is told to fill in the empty box by selecting the number which comes after a specific number (Press the button next to the number which comes after 30).

Type G

The frame is similar except the empty box has been filled with the number which was just taught and the arrow has moved above the first column of numbers. The student is told that the numbers 1, 11, 21, etc. all start a new row and so now that he knows a new number ending in one, we'll move it down and begin a new row.

Type H

A new row containing only 2 boxes appears on the screen disjoined from the previous numbers, but placed so the columns are in line. The number previously taught occupies the first box but the adjacent box is empty and the arrow points to it. The student is referred to the columns above the empty box and they are read to him in relation to their antecedent numbers (2 comes after 1; 12 comes after 11; 22 comes after 21, etc.). He is then asked what number would come next in the new series. He is told the answer and told to press the button next to it. The correct answer is the only alternative.

Type I

This is the test frame and is identical to the test frame in the earlier programs in rote counting. The numbers appear in a rectangle, a short line represents the missing number. The student is asked to press the button next to the missing number.

The teaching sequence for a typical program with 31 thru 35 used as an illustration would be as follows:

1. A_{1-30}
2. B_{3}
3. B_{11}
4. B_{21}
5. B_{9}
6. B_{30}
7. C_{31}
8. D_{31}
9. E_{31}
10. E_{31}
11. F_{31}
12. G_{31}
13. H_{32}
14. D_{32}
15. E_{32}
16. E_{32}
17. F_{32}
18. *H_{33}
19. D_{33}
20. E_{33}
21. E_{33}
22. F_{33}
23. H_{34}
24. D_{34}
25. E_{34}
26. E_{34}
27. F_{34}
28. H_{35}
29. D_{35}
30. E_{35}
31. E_{35}
32. F_{35}

Tests

33. I_{31}
34. I_{33}
35. I_{32}
36. I_{35}
37. I_{33}
38. I_{34}
39. I_{31}
40. I_{32}
41. I_{33}
42. I_{35}

*The H frames after the first presentation do not discuss moving to a new row but do discuss the new number in relation to the other numbers in the column.

The second program in each sequence does not present all the numbers previously learned, it just concentrates on the numbers in that particular series of ten. B and I frames are like the previous one except that in the B frame only one line of numbers is present.

The other frame types are as follows:

Type A

The line appears with an empty box, an arrow and only one alternative. The student is told what number belongs in that box and to press the button next to it.

Type B

Identical to previous program sequence.

Type C

The number appears in the box. The student is told what number belongs in that box and to count aloud from the beginning of that line. He is told that the new number is next after the last one he learned. He is then told to select that number from among two alternatives.

Type D

The box is empty again but the arrow is present. The student and teacher count aloud from the beginning of the line through the new number. He is then asked what number comes after the last number he learned (the response is the number he is learning). He has four alternatives.

Type E

The frame looks like the previous one. The student's previous answer is repeated to him and the counting occurs again. He is then asked the same question as in frame Type D.

Type F

The frame looks like the previous frame. The student is asked to fill in the empty box by selecting the number which comes after the last number he sees in the line.

A typical teaching sequence using 36 through 40 as an illustration would be as follows:

1. B_{33}
2. B_{34}
3. B_{31}
4. B_{35}
5. A_{36}
6. C_{36}
7. D_{36}
8. E_{36}
9. F_{36}
10. A_{37}
11. C_{37}
12. D_{37}
13. E_{37}
14. F_{37}
15. A_{38}
16. C_{38}
17. D_{38}
18. E_{38}
19. F_{38}
20. A_{39}
21. C_{39}
22. D_{39}
23. E_{39}
24. F_{39}
25. A_{40}
26. C_{40}
27. D_{40}
28. E_{40}
29. F_{40}

Tests

30. I_{35}
31. I_{37}
32. I_{40}
33. I_{39}
34. I_{39}
35. I_{38}
36. I_{36}
37. I_{40}
38. I_{36}
39. I_{38}
40. I_{37}

There are three review programs at the end of this series. They review all the numbers between 0 and 50 with the emphasis on the repetition of digits 0 through 9. This represents an attempt to provide another association to act as an aid in the retention of the sequence.

Rational Counting

Twelve distinct frames constitute this sequence. Five different objects are used to represent the quantities. These objects are: hearts, mittens, stars, houses and balls. The objects are changed from frame to frame to avert the danger of stereotyped responses. The zero program teaches the absence of a specific quantity.

Type A

The visual portion of this frame contains a group of objects with the corresponding number symbol enclosed in a circle on the left of the screen. One identical group and one other alternative group are placed next to two of the buttons. The student is told to look at the objects in the circle. He is told how many objects are contained in the circle and the objects are counted for him. He is then instructed to look at the groups of objects next to the buttons and the objects in each group are counted. His attention is redirected to the group in the circle and he is again told how many objects are contained in that group. He is then told to match that group to the correct group next to the buttons.

Type B

This frame type is like the previous one except that there are three alternatives as opposed to only two in Type A. The auditory portion is identical.

Type C

The alteration in this frame involves the inclusion of the fourth alternative. In all other respects, it is identical to frame Types A and B.

Type D

An empty circle is presented on the left of the screen so that the previous cue has vanished. Four groups of objects are placed next to the buttons. The students' attention is directed to those groups and each group is counted separately. He is then told to find a group containing the specific quantity being taught and press the button next to it.

Type E

There is a repetition of the previous visual presentation. This time, however, the objects are not counted for the student. He is told to look at the four groups and to press the button next to the one which represents a specific quantity.

Type F

Visually, this frame resembles Type A. A group of objects with the corresponding number symbol reappears in the large circle. Two alternatives are placed next to the buttons. This time, however, the corresponding number symbols are placed under the groups of objects. The students' attention is directed specifically to the number under the group inside the circle. The relationship between the number and the objects is specified. The same relationship is pointed out between the groups and number symbols next to the buttons. The student is told to press the button next to a specific quantity and its corresponding number symbol.

Type G

Again there is a repetition of the previous frame except that three alternatives are presented instead of two. The auditory presentation is identical.

Type H

Three changes are made in this frame. Visually, the cue in the circle is deleted and four alternatives are presented. Each alternative is not discussed for the student. He is told to examine the four groups carefully and to press the button adjacent to a specific quantity and its corresponding symbol.

Type I

This frame contains a quantity and its corresponding symbol in the circle and four numbers next to the buttons. The student is told to look at the quantity inside the circle and look at the numbers next to the buttons. He is told that one of the numbers tells him how many objects he sees in the circle; he is to select the correct number and press the button next to it.

Type J

In this frame the situation is reversed. The representation in the circle remains the same but the alternatives are four distinct groups of objects. The student is told to select the group which corresponds to the number symbol inside the circle.

Type E

There is a repetition of the previous visual presentation. This time, however, the objects are not counted for the student. He is told to look at the four groups and to press the button next to the one which represents a specific quantity.

Type F

Visually, this frame resembles Type A. A group of objects with the corresponding number symbol reappears in the large circle. Two alternatives are placed next to the buttons. This time, however, the corresponding number symbols are placed under the groups of objects. The students' attention is directed specifically to the number under the group inside the circle. The relationship is pointed out between the groups and number symbols next to the buttons. The student is told to press the button next to a specific quantity and its corresponding number symbol.

Type G

Again there is a repetition of the previous frame except that three alternatives are presented instead of two. The auditory presentation is identical.

Type H

Three changes are made in this frame. Visually, the cue in the circle is deleted and four alternatives are presented. Each alternative is not discussed for the student. He is told to examine the four groups carefully and to press the button adjacent to a specific quantity and its corresponding symbol.

Type I

This frame contains a quantity and its corresponding symbol in the circle and four numbers next to the buttons. The student is told to look at the quantity inside the circle and look at the numbers next to the buttons. He is told that one of the numbers tells him how many objects he sees in the circle; he is to select the correct number and press the button next to it.

Type J

In this frame the situation is reversed. The representation in the circle remains the same but the alternatives are four distinct groups of objects. The student is told to select the group which corresponds to the number symbol inside the circle.

Types K & L

These two frames are the test frames and are like the two previous frames except that the cues have been omitted. In frame K only the quantity is represented in the circle and in frame L only the number symbol is presented. The audio portion is the same. The first two programs in this series teach only two items, the last two programs teach three new items.

A typical sequence would be:

1. A_1*
2. B_1
3. C_1
4. D_1
5. E_1
6. F_1
7. G_1
8. H_1
9. I_1
10. J_1
11. K_1
12. L_1
13. A_2
14. B_2
15. C_2
16. D_2
17. E_2
18. F_2
19. G_2
20. H_2
21. I_2
22. J_2
23. K_2
24. L_2
25. L_1
26. K_2
27. L_2
28. K_1
29. K_2

Tests

30. L_2
31. L_1
32. K_1

*The number symbol represents the quantity and its corresponding symbolic representation.

Addition

Since the addition programs rely heavily on rational counting skills, some similarities between the programs were retained. The same objects were used and the same quantity configurations were maintained. The cummulative law in addition was not taught as a principle but two facts were taught and the next programs teach the reversal.

Type A

The initial frame in the addition sequence reviews one of the test frames in the rational counting sequence. The student sees a quantity in the circle and four number symbols nex to the buttons. He is asked to select the number which represents the quantity.

Type B

The quantity illustrated in the first frame remains on the left of the circle. The word and appears adjacent to that quantity and another quantity is placed to the right of the word and. The student is told the number in the first group and the number in the second group. He is told how many objects there are altogether and to count them for himself. He is then told to select the alternative which tells how many objects there are altogether.

Type C

This frame looks like the previous frame except that the word and is now underlined. The student's attention is first directed towards that word. Then the quantities are described as before but he is not told how many objects there are altogether before he is asked to make that response.

Type D

Visually, this frame is like the previous one. The word add is now introduced. The quantities are described separately and the student is told to add them together.

Type E

This frame is like the previous three frames in its visual presentation. The student is told, without any discussion to add the groups of objects together.

Type F

Numbers are introduced in this frame. The presentation continues to be horizontal. The number corresponding to each group appears under the group and the word and is moved down between the numbers. The student is told that the numbers represent the quantities and can be added together without direct reference to the quantities. Both presentations are discussed but the student is asked to respond to a question using only the numbers.

Type G

The symbol for addition is taught in this frame. The word and is moved back up between the objects and the plus sign appears underneath it. The same sign appears as the only alternative. The student is told that the sign tells you to add and is asked to find it next to the buttons and to press the button next to it.

Type H

The objects with the word and between them are still in the circle. The corresponding numbers and the addition sign, still placed horizontally, are beneath them. The students' attention is directed to the numbers but he is told to use the objects as a reference, if necessary. He is asked to add the numbers and select the correct answer.

Type I

The student sees the algorism written vertically for the first time. The answer appears on the screen. The different aspects of the algorism are pointed out to him and then the algoism is read to him and he is told to provide the answer.

Type J

The algorism with the answer remains on the screen. The objects in their corresponding places return and the relationship between the algorism and the objects is stressed. The question is still directed to the numbers, however, which the student is told to add together and provide the answer.

Type K

This frame looks like the previous one except the answer is missing from the algorism. The objects are still there and the relationship is again pointed out. The student is told to add the numbers and provide the answer.

Type L

The objects in this frame are replaced by digits which are the last cue. No reference is made to the digits and the question again refers to the numbers.

Type M

In the final frame the algorism stands alone. The student is asked to add the numbers together and select the correct answer.

Two algorisms are taught in each program, thus a typical sequence would look like:

1. A 1 +1
2. B 1 +1
3. C 1 +1
4. D 1 +1
5. E 1 +1
6. F 1 +1
7. G 1 +1
8. H 1 +1
9. I 1 +1
10. J 1 +1
11. K 1 +1
12. L 1 +1
13. M 1 +1
14. A 2 +2
15. B 2 +2
16. C 2 +2
17. D 2 +2
18. E 2 +2
19. F 2 +2
20. G 2 +2
21. H 2 +2
22. I 2 +2
23. J 2 +2
24. K 2 +2
25. L 2 +2
26. M 2 +2

Tests

27. M 1 +1
28. M 2 +2
29. M 2 +2
30. M 1 +1

The addition facts involving zero were taught separately as Appendix C illustrates. The basic sequence of the program is the same but the individual frames vary.

Type A

An empty circle is presented on the screen. That zero represents an absence of quantity is reviewed and the absence of any specific quantity in the circle is discussed. The student is instructed to find zero next to the buttons and press the button next to it.

Type B

This frame reviews the addition sign. It stands as the only alternative and the student is directed to examine it and press the button next to it.

Type C

This frame contains a quantity and a number and the student is directed to find the corresponding number next to the buttons.

Type D

The circle contains a quantity, a number and the addition sign. Again we are building the horizontal representation of the algorism. The alternatives are the addition sign and subtraction sign. The student is told to select the addition sign.

Type E

Zero becomes "nothing to add" in this frame. The zero appears without a corresponding quantity. The student is told to select the zero from the alternatives next to the buttons.

Type F

Now the process of addition begins. The frame looks exactly like the previous one. The student is told that he started with a specific quantity and added nothing to it. Then he is told how many he has altogether and immediately asked the same question.

Type G

This frame looks like frame Type F. Initially, reference is made to the quantity. This shifts in the middle of the audio presentation to the numbers and the student is asked to add the numbers.

Type H

The algorism is presented in this frame with the corresponding quantity on the left. The student is told to add the numbers together and select the answer.

Type I

Only the algorism appears in this frame. The student is told the answer and then asked what the correct answer would be.

Type J

One of the few attempts to teach a principle occurs in this frame. The algorism appears alone on the screen with the answer and the student is told to examine the problem carefully. He is then told that when you add zero to a specific quantity, your answer is identical to the quantity you started out with. This fact is made clear by an examination of the algorism. He is then told to select the correct answer to the particular problem being taught.

Type K

The algorism, without the answer is presented contained in a rectangle. The appropriate objects are placed outside the rectangle. The student's attention is directed to the algorism but he is told to refer to the objects, if necessary. He is instructed to perform the addition and select the correct answer.

Type L

The algorism is presented alone but the relationship between it and specific quantities is mentioned. The student is again told to perform the addition and select the correct answer.

Type M

This is the test frame so again the algorism stands alone. The student is reminded that he is using zero, is instructed to add and select the correct answer. Again two facts are taught, followed immediately by the reversal. The sequence is as follows:

1. A 1+0
2. B 1+0
3. C 1+0
4. D 1+0
5. E 1+0
6. F 1+0
7. F 1+0
8. G 1+0
9. H 1+0
10. I 1+0
11. J 1+0
12. K 1+0
13. L 1+0
14. M 1+0
15. A 2+0
16. B 2+0
17. C 2+0
18. D 2+0
19. E 2+0
20. F 2+0
21. F 2+0
22. G 2+0
23. H 2+0
24. I 2+0
25. J 2+0
26. K 2+0
27. L 2+0
28. M 2+0
29. M 1+0

Tests

30. M 2+0
31. M 2+0
32. M 1+0

The two programs in column addition, included as readiness for multiplication, were designed to describe the process rather than teach mastery of specific facts. Therefore, although they rely on previous experiences in addition, they differ in form.

Type A

This frame presents a review of the horizontal presentation in the original addition programs. The groups and their corresponding numbers plus the addition sign are presented on the screen. The process is reviewed for the student and he is told to select the correct answer to the addition problem.

Type B

The vertical presentation of an algorism with the corresponding groups appears on the screen. The student is again reviewed in the addition process and told to select the correct answer.

Type C

Only an algorism appears this time and the student is told to select the correct answer.

Type D

Several algorisms appear on the screen. The student is told that, although they are all different combinations and have different answers, they are alike in that each one only adds two numbers. He is told that it is possible to add more than two numbers and is instructed to press the button and learn how this is accomplished.

Type E

A column with three equal digits and corresponding quantities is presented. The student's attention is directed to the problem and it is read to him. He is told to count the objects and thus derive the answer to the problem. The answer is then told to him and he is immediately asked the answer.

Type F

The visual presentation is identical. The auditory instructions are similar except the answer is not provided.

Type G

The objects are replaced by digits in the visual presentation and the student is instructed to perform the operation and select the correct answer. He is referred to the cues.

Type H

A column addition problem where all of the digits are not equal is presented to demonstrate that it is common to perform column addition with unequal numbers. The objects are present to provide a cue to the correct answer. The student is told to perform the addition and select the correct answer.

Type I

Since these programs were designed to describe the process rather than teach mastery of certain facts, some type of cue is present in each frame. The test frame presents the fact with the digits as cues but makes no reference to the cue. The student is told to do the addition and select the correct answer.

A typical sequence would be as follows:

1. A
2. B
3. C
4. D
5. E 2+2+2
6. F 2+2+2
7. G 2+2+2
8. E 2+2+2+2
9. F 2+2+2+2
10. G 2+2+2+2
11. E 2+2+2+2+2
12. F 2+2+2+2+2
13. G 2+2+2+2+2
14. H 2+1+3
15. E 3+3+3
16. F 3+3+3
17. G 3+3+3
18. E 3+3+3+3
19. F 3+3+3+3
20. G 3+3+3+3
21. E 3+3+3+3+3
22. F 3+3+3+3+3
23. G 3+3+3+3+3
24. H 1+3+2
25. G 2+2+2+2+2
26. H 2+3+2
27. G 3+3+3
28. G 3+3+3+3
29. G 2+2+2+2
30. G 3+3+3+3+3
31. G 2+2+2
32. H 2+2+3

Tests

33. I 2+2+2
34. I 3+3+3+3+3
35. I 2+2+2+2+2
36. I 3+3+3+3
37. I 3+3+3+3
38. I 2+2+2+2
39. I 3+3+3+3+3
40. I 2+2+2
41. I 2+2+2+2
42. I 3+3+3
43. I 3+3+3
44. I 2+2+2+2+2

Subtraction

The initial subtraction programs have pictures to illustrate the concept of "take away." For example, a bird leaving a tree limb, a cookie being eaten, etc. This is abandonned after the first two programs for the less satisfactory but more economical method of drawing an X through the objects in the group that are "taken away." The first program will be described but it must be kept in mind that this change does occur in subsequent programs.

Type A

An action picture containing a specific group of objects is presented. The picture is discussed and the student is directed to designate the number of objects in the picture.

Type B

Some type of action transpires (a bird flies away, etc.) which causes the quantity to diminish. The student is asked to designate how many objects are gone.

Type C

The picture now shows only the remaining objects. The student is asked to designate the number of objects that are left.

Type D

A rectangle appears on the screen containing a group of objects similar to those used in the addition programs. The student is asked to designate how many objects are contained in the rectangle.

Type E

The rectangle with the same number of objects is presented but a designated number of objects are crossed out. The student is told that crossing them out is synonymous in this situation to taking them away. He is told how many are taken away and then asked to select that number.

Type F

The picture is identical to the previous one. The student is told that this form of quantitative manipulation is subtraction. The whole process is reviewed; how many objects were in the original group and how many were taken away. He is then asked how many are left.

Type G

An algorism is contained in the rectangle this time and the pictorial representation is on the outside. The student is told that the numbers represent what has happened to the group of objects. The specific relationship between the numbers and the objects is pointed out. The student is asked to select the answer to the number problem.

Type H

The visual display is similar to the previous one except the answer to the problem is presented with the problem. Attention is drawn to the numbers and the student is asked to select the correct answer to the subtraction problem.

Type I

The problem stands alone this time. The only alternative is the subtraction sign. The significance of the sign is discussed and the student is asked to press the button next to it.

Type J

Visually, this frame is identical to frame Type H. The discussion relates the fact to the group of objects adjacent to it and requests that the student select the correct answer.

Type K

This is another visual repetition of frame Type H. The discussion, however, draws attention to every aspect of the problem itself and then asks the student to select the correct answer.

Type L

In this frame, the algorism without the answer is placed in the rectangle. The group of objects is placed to the left of the rectangle. The relationship between the numbers and the objects is stressed and the student is asked to designate the answer.

Type M

The algorism appears alone. The student is told to remember that the numbers represent something and is then told to answer the problem.

Type N

Only the problem appears on the screen. No instructions are given except to answer the problem.

Bearing in mind the changes in frames A thru C, a typical sequence would be as follows:

1. A 2-1
2. B 2-1
3. C 2-1
4. A 2-1
5. B 2-1
6. C 2-1
7. D 2-1
8. E 2-1
9. F 2-1
10. G 2-1
11. H 2-1
12. I 2-1
13. J 2-1
14. K 2-1
15. L 2-1
16. M 2-1
17. N 2-1
18. A 3-1
19. B 3-1
20. C 3-1
21. A 3-1
22. B 3-1
23. C 3-1
24. D 3-1
25. E 3-1
26. F 3-1
27. G 3-1
28. H 3-1
29. I 3-1
30. J 3-1
31. K 3-1
32. L 3-1
33. M 3-1
34. N 3-1

Tests

35. N 3-1
36. N 2-1
37. N 3-1
38. N 2-1

The zero programs in which zero is subtracted from a specific quantity are like the regular subtraction programs with the exception of two frames.

Type A

A rectangle with a single number is presented and the corresponding quantity appears outside the rectangle. The whole process of subtraction is reviewed and the student is informed that he is going to learn to subtract using zero.

Type O

The visual presentation is identical to frame Type H. The student is told, however, another principle: that when zero is the quantity to be taken away, the remainder is the same as the initial quantity. The student is then asked to perform the subtraction and supply the answer.

A typical sequence would be as follows:

1. A 3-0
2. I 3-0
3. E 3-0
4. H 3-0
5. H 3-0
6. I 3-0
7. J 3-0
8. O 3-0
9. L 3-0
10. M 3-0
11. N 3-0
12. A 4-0
13. I 4-0
14. E 4-0
15. H 4-0
16. H 4-0
17. I 4-0
18. J 4-0
19. O 4-0
20. L 4-0
21. M 4-0
22. N 4-0

Tests

23. N 3-0
24. N 4-0
25. N 4-0
26. N 3-0

Subtracting identical quantities involves a different teaching sequence.

Type A

A circle containing a zero addition fact with a corresponding quantity appears on the screen, all the aspects of the problem are discussed, and the student is asked to perform the addition and select the correct answer.

Type B

The addition problem appears alone and the student is asked the same question as in frame Type A.

Type C

A subtraction fact with the same original quantity as in previous frames and zero as the subtrahend appears in the circle. A corresponding group is present also. The student is told to notice the sign which now tells him to subtract. He is told to perform the subtraction and select the correct answer.

Type D

The subtraction problem appears alone and the student is asked the same question as in frame Type C.

Type E

The student is prepared for a new type of subtraction problem. A specific quantity appears in the circle. He is asked to select the number which represents that quantity.

Type F

The entire quantity is "taken away" and the student is asked what he sees. He is told that he had a specific quantity to start with and that the same number was taken away so that he has "nothing left" or zero. He is asked to select zero from the alternative.

Type G

The quantity reappears with the appropriate number beside it. The student's attention is directed to the number and he is told to select the matching alternative.

Type H

A subtraction problem without the subtrahend appears in the circle and a corresponding quantity is also represented. The focus of attention is on the subtraction sign. The student is asked to descriminate between the subtraction sign and the addition sign and select the subtraction sign.

Type I

A subtraction problem is placed on the screen in which the subtrahend and the minuend are like quantities. The subtraction is represented pictorially adjacent to the fact. The student is told to select the number which tells how many are being "taken away" in this particular problem.

Type J

The same fact appears with its answer and the pictorial representation. The problem is read and the student is asked to supply the answer.

Type K

The problem appears with an answer but the illustration is absent. The problem is read and the student is told another rule that when like quantities are subtracted the answer is zero. He is then asked to supply the answer to the problem on the screen.

Type L

The problem appears without the answer. It is read, the rule is reviewed and the student is asked to supply the answer.

Type M

The problem is presented and the student is asked to supply the answer. This is the test frame.

Only one fact is taught in each program so the typical teaching sequence would be:

1. A 1 0
2. G 1 0
3. C 1-0
4. D 1-0
5. E 1-1
6. F 1-1
7. E 1-1
8. F 1-1
9. E 1-1
10. F 1-1
11. G 1-1
12. H 1-1
13. I 1-1
14. J 1-1
15. K 1-1
16. L 1-1
17. M 1-1

Tests

18. B 1 0
19. M 1-1
20. D 1-0

Multiplication

A series of programs designed to provide a foundation for formal instruction in multiplication precedes the actual multiplication programs. The student is instructed in the process of column addition of like numbers and is taught to count by two's and fives. Recognition of the multiplication sign is also taught.

Several programs are included in this "readiness" state which teach the student to look at a total group of objects, divide those objects into a specific number of equal groups, and then determine the total number of objects in each group. The student is also taught to see the relationship between the total quantity, after the division has taken place, and the original quantity. Another set of programs in this sequence teaches the concept of equal quantities.

Two different types of multiplication programs were developed. The first type is used with 2 and 5 problems and its primary difference is that it teaches the commutative law as a separate principle. The frame types for the 2 and 5 programs are described as follows:

Type A

The student sees a group of objects on the screen. He is reminded that he is learning to multiply and is asked to count the objects in the group and press the button next to the appropriate answer.

Type B

The student sees that same quantity divided into a specific number of groups. His previous answer is repeated to him and he is told that those objects have been made into groups. He is then asked how many objects are contained in each group.

Type C

The visual display is similar to Type B except that the alternatives are the words "yes" and "no." The student is told how many objects are in each group and then asked if the groups are equal.

Type D

The visual portion is identical to Type B. The student is asked how many groups are on the screen.

Type E

The original quantity reappears placed in groups but not encircled. A column addition problem with the corresponding number adjacent to the appropriate quantity is presented also. The problem is read to the student and he is asked to perform the addition and select the correct answer.

Type F

This frame was designed to review the multiplication sign. The three signs which he knows occupy positions next to the buttons and he is told to select the multiplication sign.

Type G

The original quantity reappears encircled in specific groups. A square with a number in it is positioned next to the objects. The student is reminded that he identified the number of objects in each group and that number has been placed in the box. He is asked to select the number which tells how many groups there are.

Type H

The pictorial representation is the same but a complete multiplication problem has appeared in the square. The different elements of the problem are pointed out to the student and the problem is read to him. He is then asked the answer and told to count the hearts, if necessary.

Type I

A multiplication problem with the answer appears in the square. The problem is read to the student and he is asked to supply the answer.

Type J

A line of circles containing dots appears on the screen. The process of multiplication is reviewed for the student:

You must know how many groups you have

You must know how many objects in each group

You must know if the groups are equal

The student is then asked how many dots are contained in each circle.

Type K

The student's answer is placed on the screen. The circles are moved to the top of the screen. The student is asked how many groups are on the screen.

Type L

The student's answer is placed on the screen under the other number and a multiplication problem is developed. The student is asked to answer the problem and to refer to the circles if he needs help.

Type M

The column addition problem and its related multiplication problem appear on the screen. The student is told that it is shorter to add than multiply but that the answers are the same. He is asked to select the right answer to both problems.

Type N

The multiplication problem appears with the answer. The problem is read to the student and he is told to select the correct answer.

Type O

The objects reappear, appropriately grouped, and the corresponding problem without the answer appears in the box. The problem is read and the student is asked to supply the answer.

Type P

The problem without the answer appears and the student hears the problem and is told to answer it.

Type Q

The problem appears and the student is told to answer it. This is the test frame.

A typical teaching sequence would be:

1. A 2x4
2. B 2x4
3. C 2x4
4. D 2x4
5. E 2x2x2x2

21. H 2x5
22. I 2x5
23. J 2x5
24. K 2x5
25. L 2x5

Tests

42. Q 4x2
43. Q 4x2
44. Q 5x2
45. Q 6x2
46. Q 5x2

6. F 2x4

7. G 2x4

8. H 2x4

9. I 2x4

10. J 2x4

11. K 2x4

12. L 2x4

13. M 2x4

14. N 2x4

15. O 2x4

16. P 2x4

17. Q 2x4

18. E 2x2x2x2x2

19. B 2x5

20. G 2x5

26. M 2x5

27. N 2x5

28. O 2x5

29. P 2x5

30. Q 2x5

31. G 2x6

32. H 2x6

33. I 2x6

34. J 2x6

35. K 2x6

36. L 2x6

37. M 2x6

38. N 2x6

39. O 2x6

40. P 2x6

41. Q 2x6

47. Q 6x2

After each one of these programs, the same facts are reversed and the commutative law is taught. The description of this type of program is as follows:

Type A

The fact in its original form is presented on the screen. The student is told the law; when you reverse the position of the numbers in a multiplication problem the answer stays the same. He is then told that we'll work this out so he can see what happens but that he must first answer the problem, which he has already learned, on the screen.

Type B

The original problem appears again with the objects properly grouped beside it. He is reviewed as to what each number in the problem means in relation to the objects and is again asked to answer the problem.

Type C

The old problem and the new one (the reverse of the old) appear side by side on the screen. The method by which the new one, which has an arrow under it, was derived is explained to the student. He is told that the answer to both problems is the same and to select the right answer from the list of alternatives.

Type D

The old problem with its pictorial representation is left on the screen at the top. A new picture representing the new problem appears next to an arrow at the bottom of the screen and the student is told to select the number which tells how many objects are contained in the new groups.

Type E

The old picture still remains and the new picture with the student's answer to the previous question are present at the bottom of the screen. The words "yes" and "no" are present next to the buttons. The student is asked if the new groups are equal.

Type F

In this frame, the old picture and problem still remain at the top and the new picture and a multiplication problem without the multiplier is present at the bottom of the screen. The student is asked to examine the new picture and to press the button next to the number which tells how many groups are present in the new picture.

Type G

The new problem and its corresponding picture are presented alone and the student is asked to select the answer to the problem.

Type H

Only the pictures of the two problems properly grouped are presented on this frame. "Yes" and "No" are again the alternatives. The student is asked to count the number of objects in each set and is asked if they both contain the same number.

Type I

Again both problems appear and are read to the student who is told that the answer to both is the same and to supply the answer.

Type J

The new problem, with its answer appears on the screen. The alternatives are three multiplication problems, one being the reverse of the problem being taught. The problem by itself is read to the student and he is instructed to find the problem next to the buttons which will give exactly the same answer as the problem by itself.

Type K

The problem appears by itself and the student is asked to supply the answer. This is one of the test frames.

Type L

The problem appears on the screen and three multiplication problems appear next to the buttons. The student is instructed to press the button next to the problem which will give the same answer as the problem by itself. This is another of the test frame.

A typical teaching sequence would be:

1. A 4x2
2. B 4x2
3. C 4x2; 2x4
4. D 2x4
5. E 2x4

13. A 5x2
14. B 5x2
15. C 5x2; 2x5
16. D 2x5
17. E 2x5

25. A 6x2
26. B 6x2
27. C 6x2; 2x6
28. D 2x6
29. E 2x6

6. F 2x4
7. G 2x4
8. H 2x4; 4x2
9. I 2x4; 4x2
10. J 2x4
11. K 2x4
12. L 2x4

18. F 2x5
19. G 2x5
20. H 2x5; 5x2
21. I 2x5; 5x2
22. J 2x5
23. K 2x5
24. L 2x5

30. F 2x6
31. G 2x6
32. H 2x6; 6x2
33. I 2x6; 6x2
34. J 2x6
35. K 2x6
36. L 2x6

The multiplication programs for 3 and 4 follow a slightly different pattern. In every case where a multiplication fact is repeated, it is treated as a review of a fact previously learned. The frame description for these facts is as follows:

Type A

A multiplication problem with its answer appears on the screen. The problem is read to the student; the answer is pointed out to him and he is told to find the answer next to the buttons.

Type B

The same problem without the answer is presented. A dot picture representing the problem is also presented. The student is told that the dots explain what is happening in the problem and the relationship is pointed out. The problem is then read and the answer provided and the student is told to locate the answer next to the buttons.

Type C

A column addition problem with a dot representation beside it corresponding to the multiplication problem being taught appears on the screen. The student is told to add and select the correct answer.

Type D

Both the addition problem and the multiplication problem appear together. The student is asked if the answers to both are the same. He can choose from two alternatives: yes or no.

Type E

The original problem and its dot-picture representation, and the reverse of that problem with an answer and its dot picture representation, appear on the screen. The student is reminded of the rule about reversing the numbers and both problems are read to him. He is told that both answers are the same and to select the correct answer.

Type F

The first problem with its dot representation appears on the screen. The student is told that he has seen four new problems and he is going to practice them until he knows them well. He is told to look at the problem, it is read to him, and he is told to select the correct answer.

Type G

The student sees the problem with the dots and he is asked the answer.

Type H

The student sees the problem with the dots and the word "times" is used. He is asked to select the correct answer.

Type I

The student sees the problem without the dots and is asked to provide the answer. This is the test frame.

A typical teaching sequence would be as follows:

1. A 3x1
2. B 3x1
3. C 3x1
4. D 3x1
5. A 3x2
6. B 3x2
7. C 3x2

14. I 3x1
15. F 3x2
16. G 3x2
17. H 3x2
18. I 3x2
19. F 1x3
20. G 1x3

Tests

27. I 3x1
28. I 2x3
29. I 1x3
30. I 3x1
31. I 3x2
32. I 2x3
33. I 1x3

8. D 3x2

9. E 3x1; 1x3

10. E 3x2; 2x3

11. F 3x1

12. G 3x1

13. H 3x1

21. H 1x3

22. I 1x3

23. F 2x3

24. G 2x3

25. H 2x3

26. I 2x3

34. I 3x2

Division

As was mentioned previously, only one type of division was taught. In the program which teaches recognition of the division sign (A-126), both division symbols ⟌ and ÷ were illustrated. However, only one (⟌) was taught for mastery and it is the only one which is used in the division program. Program A 127 directs the student through the steps of taking a specific group, breaking it into a specific number of smaller equal groups and both counting the groups and counting the number in each group. It relies on the perceptual skills developed in the multiplication readiness programs.

Division problems utilizing 3, 4 and 5 are sequenced alternately with corresponding multiplication problems. The division programs using 2 are grouped separately because it is in them that the emphasis is on teaching the process. The frame types for the two facts in division are as follows:

Type A

The student sees a group of objects appear on the screen. He is reviewed on the process of dividing a large group into smaller equal groups and counting the groups. He is told that he is going to learn to attach numbers to that process. He is told to count the objects in the total group on the screen and press the button next to the appropriate number.

Type B

This time the same group of objects is divided into a specific number of equal groups. The question is asked, "How many objects are in each group?" The student is instructed to respond.

Type C

The frame looks like the previous one except that there are no alternatives. The student is lead through the relevant questions in this type of division:

How many objects in total group?

How many equal groups are to be made?

How many objects will be contained in each group?

He is told that he can use numbers to illustrate the same process and to press the button and he will learn how it is done.

Type D

From the four signs, the student is asked to select the division sign.

Type E

This frame presents a group of objects at the top and a rectangle containing the division sign at the bottom. The different elements of the visual display are pointed out and the student is prepared to begin using numbers. The student is asked to press the button next to the number which tells how many objects are contained in the group on the screen.

Type F

The student's answer is placed under the division sign in the box and his attention is directed to it. The objects are divided into a specific number of groups and the student is asked to select the number which tells how many groups have been made.

Type G

That answer becomes the divisor of the problem which is being built in the box and the student's attention is directed to it. Now the student is asked how many lollipops are contained in each group.

Type H

Again the student's answer is appropriately placed in the division problem and his attention is directed to it. The box now contains a completed division problem and it is read to him in relation to the manipulation of the pictured objects. There are no alternatives on this frame so he is told to press the button and division will soon take place without showing the objects.

Type I

The problem appears in the box and the pictorial representation is placed next to one of the buttons. The elements of the number problem are discussed and the student is told that those numbers demonstrate what has happened to the objects next to one of the buttons. He is told to look at them carefully and to remember that they mean essentially the same thing. He is then told to press the button next to the objects.

Type J

The problem without the answer and the objects appear on the screen. The student is asked how many objects will be contained in each group if he has a specific number of objects and divides them into specific number of equal groups.

Type K

Only the problem appears on the screen. The relationship between the numbers and the objects is drawn and the student is asked to do the division and select the answer.

Type L

This is the test frame. The problem appears and the student is asked to provide the answer.

1. A $2\overline{)2}$
2. B $2\overline{)2}$
3. C $2\overline{)2}$
4. D $2\overline{)2}$
5. E $2\overline{)2}$
6. F $2\overline{)2}$
7. G $2\overline{)2}$
8. H $2\overline{)2}$

19. G $2\overline{)4}$
20. H $2\overline{)4}$
21. I $2\overline{)4}$
22. J $2\overline{)4}$
23. K $2\overline{)4}$
24. L $2\overline{)4}$
25. A $2\overline{)6}$
26. B $2\overline{)6}$

Tests

37. L $2\overline{)2}$
38. L $2\overline{)6}$
39. L $2\overline{)6}$
40. L $2\overline{)4}$
41. L $2\overline{)2}$
42. L $2\overline{)4}$

9. I 2)2
10. J 2)2
11. K 2)2
12. L 2)2
13. A 2)4
14. B 2)4
15. C 2)4
16. D 2)4
17. E 2)4
18. F 2)4

27. C 2)6
28. D 2)6
29. E 2)6
30. F 2)6
31. G 2)6
32. H 2)6
33. I 2)6
34. J 2)6
35. K 2)6
36. L 2)6

Some minor changes are made in the division problems for 3, 4 & 5. Frame Type A is changed and frame Types C, D and I are deleted after the first fact. A few problems are repeated and these are designated as review problems. Two facts are taught in most of these programs. The change in the initial frame is as follows:

Type A

The related multiplication fact from the previous program appears on the screen. Underneath this is a group of objects identical in quantity to the answer to the multiplication problem. The student is reviewed on the multiplication fact and then it is suggested that the multiplication problem be converted into a division problem. The specific relationship between multiplication and division is drawn on subsequent programs and this will provide a foundation for that conceptualization. The student's attention is drawn to the group of objects and he is asked to press the button next to the number which tells how many objects are contained in that group.

The teaching sequence for these programs is as follows:

1. A 1x3
2. B 1)3
3. C 1)3

11. K 1)3
12. L 1)3
13. A 3x1

Tests
22. L 3x1
23. L 3)3
24. L 3)3

4. D 1)3

5. E 1)3

6. F 1)3

7. G 1)3

8. H 1)3

9. I 1)3

10. J 1)3

14. B 3)3

15. E 3)3

16. F 3)3

17. G 3)3

18. H 3)3

19. J 3)3

20. K 3)3

21. L 3)3

25. L 3x1

Review of Four Basic Processes

The initial program in this series reviews the four computational signs. The test for mastery is two fold: the ability to select a specific sign when asked and the ability to look at a problem complete with the answer and select the appropriate sign.

Two programs are contained in this unit which utilize a specific group of objects and manipulate them through the processes of addition, subtraction, multiplication, and division. This illustrates an attempt to review the four processes and to point out the relationships which exist between the processes.

The largest group of programs in this unit review specific sets of algorisms. A frame by frame description of these programs follows.

Type A

Four problems are presented next to the buttons; an addition, subtraction, multiplication and division problem. The same problems will remain throughout the program and they all utilize the same numbers (2x2; 4—2; 2x2 and 2)4). The student is told that he knows the answers to these problems. He is also told that they represent different processes but they utilize the same numbers. He is instructed to press the button next to the addition problem.

Type B

The addition problem appears on the screen. The student is told that he selected the correct problem and that it now is on the screen. The problem is read to him and he is told to select the answer.

Type C

The addition problem with its answer appears at the top of the screen. A box is presented containing a subtraction problem composed of the answer to the addition problem as the minuend and one of the addends as the subtrahend. Both problems are read to the student and the similarity of the numbers is discussed. The student is asked to select the answer to the subtraction problem.

Type D

The addition problem and subtraction problem with their answers are placed side by side on the screen. The addition problem is read and the student is told that the subtraction problem is made by taking the answer to the addition problem and subtracting one of the addends. The answer is the other addend. The student is then told to press the button to learn how to use this information.

Type E

The subtraction problem is written at the top of the screen. In the box, the addition problem is written. The student is told that this addition problem is the remainder and subtrahend (technical terms are not used with students) of the subtraction problem. He is then instructed to press the button next to the answer to the addition problem.

Type F

The subtraction problem with its answer is shown on the screen. The addition problem and its answer is also shown. The alternatives are the four original problems. The student is told that the top number in the subtraction problem and the bottom number in the addition problem are the same. He is told that this is the method of checking subtraction. He is told to add his answer and the number above the line and if his answer is the same as the top number in the subtraction problem, he will know he subtracted correctly. He is then told to press the button next to the multiplication problem.

Type G

The multiplication problem is on the screen. It is read to the student and he is told to press the button next to the answer.

Type H

The multiplication and addition problems are presented side by side. The alternatives are the words "yes" and "no." The student is told to look carefully at the two problems. He is told that one is an addition problem and the other a multiplication problem. He is asked if the answer to both problems is the same.

Type I

The multiplication and addition problems are on the screen with their respective answers. The four original problems are next to the buttons. The student is told that the answer to both problems was the same and reminded that multiplication is a short form of addition. He is then asked to press the button next to the division problem.

Type J

The division problem is read to the student and he is told to select the answer to it.

Type K

The division problem with its answer is presented on the screen. The student is told to press the button and he can look at all four of these problems together.

Type L

All of the problems and their answers are presented at the top of the screen. The problems are repeated in a box at the bottom of the screen but a number, the same in each case, is missing from each problem. The missing number is represented by a small box. The problems at the top are each read to the student. The student is then told to look at the problems in the box. He is told that a number is missing from each problem and that the little box stands for the missing number. He is told that the same number is missing from each problem. He is told to decide on the missing number and to press the button next to it.

Type M

This frame is repeated 12 times in the program. It is used three times with each of the four processes. A problem complete with the answer appears at the top of the screen. The same problem is presented in a box lower down on the screen with one number missing. A different number is missing from each of the three presentations for a specific process. The student is told that he is going to play a "missing numbers" game. He is reminded that the little box represents the missing number. He is told to refer to the problem at the top if he needs help. He is then instructed to find the missing number and press the button next to it.

Type N

This frame differs from the previous one in that a completed problem is not presented as a cue. The student is told to look at the problem on the screen. He is reminded that a number is missing from the problem and told to examine it carefully so that he can determine what kind of problem it is. He is then told to select the missing number and to press the button next to it. There is only one repetition of this frame for each of the four processes.

Type O

All four problems are presented simultaneously. A number is missing from each problem. The student is told to select the missing number. Each time this frame is presented, a different number is missing. This is a test frame.

Type P

This represents the second type of test frame. All four problems are presented next to the buttons. The student is told to select a specific problem. A different problem is requested each time the frame is repeated.

A typical teaching sequence would be as follows:*

1. A 2+2
2. B 2+2
3. C 4-2
4. D 2+2; 4-2
5. E 2+2
6. F 4-2; 2+2
7. G 2x2
8. H 2+2; 2x2

19. M 2x2
20. M 2x2
21. M 2x2
22. M $2\overline{)4}$
23. M $2\overline{)4}$
24. M $2\overline{)4}$
25. N 2x2
26. N $2\overline{)4}$

9. I 2+2; 2x2

10. J $2\overline{)4}$

11. K $2\overline{)4}$

12. L 2+2; 2x2; 4-2; $2\overline{)4}$

13. M 2+2

14. M 2+2

15. M 2+2

16. M 4-2

17. M 4-2

18. M 4-2

27. N 4-2

28. N 2+2 Tests

29. O_2

30. P 2x2

31. P 4-2

32. O_2

33. P $2\overline{)4}$

34. P 2+2

35. O_4

* in this instance the items are

$$\begin{array}{r}2\\+2\\\hline\end{array}\qquad\begin{array}{r}4\\-2\\\hline\end{array}\qquad\begin{array}{r}2\\x2\\\hline\end{array}\qquad 2\overline{)4}$$

Fractions

Only one of the four basic concepts of fraction was taught--the concept which involves understanding a fraction as a part of a whole. The decision not to teach fractional parts of a group or fractions as an indicated division of ratio was based on the fact that these concepts were considered beyond the scope of this project.

Very little emphasis was placed on comparisons of evenly and unevenly divided portions, although unevenly divided objects were used as alternatives. This type of instruction does not permit the manipulation and exploration by the learner which is essential to fine discriminations and so it would have been too difficult to teach anything other than gross comparisons.

In the first set of programs, four types of problems are presented:

(a) selection of a whole which has been divided into a specific number of parts

(b) determining the number of parts in a specific division

(c) comparing the size of the parts in a specific division

(d) selecting a specific fractional part.

The different frame types are described as follows:

Type A

The student sees a whole object and the essential characteristics of a whole are explained to him (no cuts, no missing parts, etc.). He is then instructed to look at the object on the screen and the specific characteristics which make it a whole are discussed. He is told to press the button and the lesson will be continued.

Type B

The same object is divided in half and the pieces are separated slightly. The student is asked to count the number of pieces and select the number next to the buttons which tells him how many pieces there are on the screen (initially, he selects from only two alternatives but as the sequence progresses, the number of alternatives increases).

Type C

The pieces are placed side by side on the screen. The alternatives are words "yes" and "no." The student is asked if the pieces are the same size.

Type D

The object, cut in half, appears on the screen. There are no alternatives. The student is told the two important things concerning fractional parts of a whole; the relationship between the fraction and the number of portions, and the fact that all portions must be equal. The specific fraction is related to the pictorial representation and the student is told to press the button and he will receive further instruction.

Type E

Characteristics of a whole object are pointed out to the student. A whole object is presented on the screen and another whole object is presented as an alternative. The student is required to match and press the button next to the whole object.

Type F

A whole object and an object divided into fractional parts are presented next to the buttons. The characteristics of both are discussed and the student is asked to select the whole object.

Type G

The alternatives are the same as before, however, their respective characteristics are not discussed. The student is instructed to select the whole object.

Type H

An object divided into fractional parts is presented. It's properties are discussed and the fractional representation is presented. The only alternative is an identical representation. The student is required to match and press the button next to the divided object.

Type I

The visual display is identical. This time, however, the student is instructed to select the one which has been divided into specific parts. The properties of each are discussed.

Type J

Four objects with different cuts representing a specific fraction (1/2) are presented. There are no alternatives. The student is told that the precise position of the division is irrelevant as long as the characteristic of equal piece size is satisfied. He is told to press the button and he can review his understanding of the concept.

Type K

The object is represented with a specific fractional portion missing (The missing portion is represented by a broken line). A whole object and certain fractional portions comprise the alternatives. The student is told to select the correct portion. This is used as a test frame, too.

Type L

Four objects, one whole and three representing different divisions are presented. The student is asked to select a specific fractional division and press the button next to it.

This is a test frame.

Type M

This is a test frame also. Four numbers are presented next to the buttons. The student is asked how many pieces will be made by a specific fractional division.

Type N

Four different objects cut in the same fractional parts are presented. The student is asked whether or not they actually represent the same fractional division.

This is also a test frame.

Six different types of objects are used in these programs: a pie, cookie, chocolate bar, heart, circle, and square. Only four of them are selected for any single program.

The teaching sequence for a typical program in the series is as follows:

1. A 1/2 pie
2. B 1/2 pie
3. C 1/2 pie
4. D 1/2 pie
5. E 1/2 pie
6. F 1/2 pie
7. G 1/2 pie
8. B 1/2 pie
9. C 1/2 pie
10. H 1/2 pie

21. E 1/2 heart
22. H 1/2 heart
23. I 1/2 heart
24. K 1/2 heart
25. E 1/2 box
26. B 1/2 box
27. C 1/2 box
28. H 1/2 box
29. I 1/2 box
30. J 1/2 box

11. I 1/2 pie

12. J 1/2 pie

13. K 1/2 pie

14. E 1/2 circle

15. F 1/2 circle

16. B 1/2 circle

17. C 1/2 circle

18. H 1/2 circle

19. J 1/2 circle

20. K 1/2 circle

31. K 1/2 Tests

32. L 1/2 circle

33. K 1/2 pie

34. L 1/2 pie

35. K 1/2 heart

36. M

37. L 1/2 heart

38. L 1/2 box

39. K 1/2 box

40. N

The second set of programs in this series teaches the numerical representation of the three fractions (1/2, 1/4 and 1/3) and then relates them to a pictured representation of the appropriate fractional part.

The frame types for this series are described as follows:

Type A

A single object is presented. It is described as a whole object and then the student is asked "how many" object he sees and instructed to make the appropriate response.

Type B

The object reappears with the number one underneath it. The student is told that a whole object is one object. He is told that the number one describes the whole object. Then he is told to find the number next to the buttons which tells about the whole object and to press the button next to it.

Type C

The object is presented again. The student is asked to select the number which describes the whole object and to press the button next to it.

Type D

The whole object is presented divided into fractional parts. The student is asked to press the button next to the number which tells how many pieces there are.

Type E

The object is presented with a fractional part missing. The missing part is represented by a broken line. Different portions of the object are presented next to the buttons. The student is told to select the portion which represents the missing part.

Type F

A fractional part of the object is presented. The appropriate numerical fraction is presented next to the buttons. It is described in detail, related to the object and the student is instructed to press the button next to it.

Type G

The numerical fraction is written under the fractional part of the object. The numerical fraction is the only alternative.

The relationship between the number and the picture is described. The student is instructed to press the button next to the fraction.

Type H

The fraction appears alone. There are 2 alternatives; the fraction and a whole number. All of the elements of the fraction are described to the student and he is told to select it from the alternative.

Type I

This is similar to the previous frame except there are 3 alternatives; 1 whole number and 2 fractions. The student is told to select the correct fraction.

Type J

This frame is like the two previous ones except there are now four alternatives; 1 whole number and three fractions. All the elements of the fraction are discussed.

Type K

Four alternatives are presented and the student is instructed to select a specific fraction. This is used as a test frame.

Type L

This is similar to frame Type G except there are four alternatives.

Type M

A fractional part of an object appears and the student is instructed to select the appropriate numerical fraction. There are 2 alternatives.

Type N

A fraction is presented and the student is instructed to select the appropriate fractional representation of an object. There are two alternatives.

Type O

This is similar to Type M except there are four alternatives.

This is used as a test frame.

Type P

This is similar to Type N except there are four alternatives. This is used as a test frame.

A typical teaching sequence for this series would be:

1. A* (pie
2. B
3. C
4. D
5. E
6. F
7. G

18. C (cookies)
19. M
20. O
21. P
22. C (heart)
23. M
24. O

8. H

9. I

10. J

11. J

12. K

13. L

14. M

15. N

16. O

17. P

***teaching 1/2**

25. P

Tests

26. P 1/2 heart

27. K

28. P 1/2 cookie

29. O 1/2 pie

30. K

31. O 1/2 cookie

32. P 1/2 pie

33. O 1/2 heart

The final program in this unit (A 175) compares the three fractions in relation to size and relationship to the whole. It requires that the student be able to discriminate between the three fractions which were taught.

Chapter 7

Procedure

Design and Sample

Although the primary independent variable of this study was method of instruction, it was felt that age might also be an important determinant of change in academic achievement and behavior. For this reason, the study was originally conceived as a 2x2 factorial design for many of the major analyses. One of the variables was method of instruction (teaching machines plus regular instruction vs. regular instruction) and the other was age of Ss (younger vs. older). The older groups were designated E_1 (teaching machine) and C_1 (no teaching machine) whereas the younger groups were designated E_2 and C_2.

The dependent variables of the study were the difference scores obtained between testing at the end of the school year (post-test) and at the beginning of the school year (pre-test) on a number of achievement tests and behavior ratings.

The objective of the project was to present beginning reading and arithmetic to mentally retarded children. Therefore, Ss had to be selected who had little or no formal skills in the tool areas with mental ages no higher than approximately seven years.

Since the resident population of boys and girls at the Johnstone Center measures from 12 to 21 years in chronological age and is exposed to a formal academic program, the large majority of students measured too high in achievement to participate in beginning reading and arithmetic programs. A nearby State Institution, the New Lisbon State Colony for boys, was selected to supply additional younger Ss. The new residents extended the lower age limit to 10 years and, together with previously selected male and female Ss, afforded sufficient population for the establishment of four groups of ten Ss each: two machine and two non-machine groups. The older machine and non-machine groups each included 8 males and 2 females. The younger groups were all male. An attempt was made to equate each experimental group with its control counterpart using IQ, CA, and achievement levels as criteria. The resultant means ($\overline{X}$) and standard deviations (SD) for the original experimental (E_1 and E_2) and control (C_1 and C_2) groups were as follows:

Table 7.1

Description of Original Machine and Non-Machine Groups.

	E_1		C_1	
	$\overline{X}$	SD	$\overline{X}$	SD
CA	15.5	.50	15.3	.76
IQ	54.6	5.41	56.7	4.90
Rd. Gr.	1.6	.50	1.6	.59
Ar. Gr.	2.0	.65	2.0	.54
N	10		10	
	E_2		C_2	
	$\overline{X}$	SD	$\overline{X}$	SD
CA	12.3	1.70	12.8	1.63
IQ	55.0	6.17	53.6	10.72
Rd. Gr.	1.2	.68	1.1	.36
Ar. Gr.	1.5	.45	1.5	.49
N	10		10	

Due to transfers, discharges, new admissions and other extenuating circumstances during the course of the project beyond the control of the experimenters, the original younger groups overlapped the older groups to such an extent that the age dichotomy was abandoned in favor of combined E and C groups as shown in Table 7.2. t-tests confirmed the expectation that there were no significant differences between groups on any of the variables listed.

Instrumentation

At the start of the school year, Ss were administered the Wide Range Achievement Test (WRA), the Wechsler Intelligence Scale for Children (WISC), the Metropolitan Achievement Test (MAT), pre-primary or primary, and specially devised tests of reading and arithmetic (C&G) which were constructed to measure performance specifically on material included in the programs. The C&G was

Table 7.2

Description of Combined Machine E_1 and E_2 and Non-machine C_1 and C_2 Groups upon which Final Data were Collected

	Comb. E		Comb. C	
	X	SD	$\overline{X}$	SD
CA	14.1	.94	14.3	1.61
IQ	54.3	8.07	54.2	7.55
Rd. Gr.	1.3	.49	1.4	.52
Ar. Gr.	1.7	.59	1.7	.58
N	19		17	

Note: In subsequent analyses N's vary slightly in accordance with availability of Ss.

readministered at mid-year and the full battery of tests was repeated at the end of the school year.

Teachers were instructed in the use of the Behavior Rating Basal Scale (BRBS)* and asked to rate each S once a month in accordance with the former's general impression of the child's behavior. Utilizing the same behavior scales, each S was rated by a trained observer, once a month, by a time-sampling technique which included ten consecutive minutes of observation per child on randomly selected days of the week. This afforded two distinct measures of classroom performance each month.

As a measure of out-of-school behavior, negative Progress Notes for each child were tabulated for the first two and last two months of the school year. These notes are reports of dormitory and other non-school behavior. School Progress Notes were also noted for the same period.

***Developed by Dr. Harriet Blodgett, Director, Sheltering Arms, a day school for the mentally retarded in Minneapolis, Minnesota (See Appendix D).**

Classroom Procedure

The experimental classroom was used by one of the E groups in the morning and the other E group in the afternoon. The room was equipped with five teaching machines banked along one side of the room facing away from the center. This arrangement afforded ample space and a relatively distraction-free atmosphere for teaching Ss awaiting their turn at the machines. For all Ss in each E group to receive an equal number of programs, the limited half-day schedules and the necessity for repetition of programs for certain Ss--the criterion of 50% learning was established for each pupil per program--the total number of programs covered each week was necessarily restricted. The average number of new program exposures per S per week fell between 2 and 3 each on reading and arithmetic amounting to approximately 2 hours of machine time per week of a 10 hour school week. Teachers of the C groups were instructed to cover the same materials and maintain the same pace as the E groups. Theoretically, therefore, at any given point in the school year, the E and C groups had been exposed to equivalent materials. Due to the somewhat slow rate at which Ss were exposed to programs, only a minority of available programs were presented. Of the 20 units of reading material available (see Appendix B), Ss in both the E and C groups only progressed through Unit 4. Thus, of a total of 218 reading programs that had been constructed, 55 were actually used in the evaluation phase of this Project. Of the 175 arithmetic programs developed, 54 were used.

In the E groups, before each S was exposed to his teaching machine program, he was pre-tested on the content of the program. Immediately following his machine experience he was retested on the same material. If 50% learning was not achieved, the S was given a second (and final) exposure to the same program. At the end of each week, retention scores were obtained on all programs covered that week. Since certain programs were given on Monday, Tuesday, etc., and retention measures were restricted to Fridays, it was possible to isolate 1, 2, 3, and 4 day retention scores on specific programs in addition to the mid-year (C&G only) and final achievement measures.

Two teachers were selected and each assigned to an E and C group; i.e., one teacher had the responsibility for an E group in the morning and a C group in the afternoon while the other had the reverse schedule. At mid-year, the teachers exchanged assignments.

With five teaching machines in one classroom operating simultaneously, and with each S proceeding at his own rate, the necessity for changing tapes and film strips frequently would have placed an indefensible burden upon the teacher. Consequently, older mentally retarded residents were trained and assigned as "teaching machine assistants" in the E classroom. In addition to changing tapes and film strips, these assistants also had the responsibility for procuring appropriate programs daily from the program storage area and making minor adjustments to the hardware.

Statistical Analysis

All comparisons between E and C groups on the dependent variables were analyzed by appropriate t-test and analysis of variance procedures. For the evaluation of the significance of mean differences the .05 level of confidence was employed.

Chapter 8

Results

The primary objective of this phase of the research was to measure the improvement and compare the achievement of the E and C groups over the experimental period. As indicated in the previous chapter, the achievement devices used to evaluate this growth were the MAT, the WRA, and the C&G. The tabular material which follows presents two types of data for each test: (1) the means ($\bar{X}$) and standard deviations (SD) of the pre- and post-test scores of both the E and C groups as well as appropriate t-tests for evaluating the statistical significance of the changes in these scores; and (2) the $\bar{X}$s and SDs of the pre-post difference scores of the two groups and t-tests to determine whether there were any significant differences between these difference scores.

Reading Achievement

Table 8.1 presents a summary of data and analyses of the significance of improvement from pre- to post-tests for E and C on MAT-Reading. It is clear that the mean gain of .24 of a grade for E and .21 for C represents a statistically significant improvement beyond the .01 level.

Table 8.1

$\bar{X}$s, SDs and t-tests between Pre- and Post-test MAT Grade Level Scores (Reading) for E and C Groups

		Pre-test	Post-test	gain	t	p
	$\bar{X}$	1.55	1.79	.24	5.85	$<.01$
E	SD	.51	.47			
	N	19	19			
	$\bar{X}$	1.51	1.72	.21	4.08	$<.01$
C	SD	.45	.57			
	N	16	16			

Table 8.2 presents summary data and evaluates the significance of the difference between the E and C pre-post mean difference scores on MAT-Reading. The obtained t value of .47 ($p > .05$) demonstrates that there was no significant difference between improvement scores for E and C.

Table 8.2

$\overline{X}$s, SDs, and t-tests between E and C Pre-Post MAT Grade Level Difference Scores (Reading)

	E	C	diff.	t	p
Mean Pre-Post Diff.	.24	.21	.03	.47	N.S.
SD	.16	.20			
N	19	16			

Table 8.3 presents a summary of data and analyses of the significance of improvement from pre- to post-tests for E and C on WRA-Reading. Similar to the MAT-Reading findings, the mean pre-post WRA-Reading gain scores of .24 and .34 for E and C, respectively, represented statistically significant improvement beyond the .01 level. Table 8.4, however, illustrates that there was no significant difference ($t = 1.41$, $p > .05$) between the E and C mean gain scores.

Table 8.3

$\overline{X}$s, SDs, and t-tests between Pre- and Post-test WRA Grade Level Scores (Reading) for E and C Groups

		Pre-test	Post-test	gain	t	p
E	$\overline{X}$	1.43	1.67	.24	4.93	<.01
	SD	.49	.57			
	N	18	18			
C	$\overline{X}$	1.42	1.76	.34	7.02	<.01
	SD	.56	.62			
	N	16	16			

Table 8.4

$\overline{X}$s, SDs and t-tests between E and C Pre-Post WRA Grade Level Difference Scores (Reading)

	E	C	diff.	t	p
Mean Pre-Post Diff.	.24	.34	.10	1.41	N.S.
SD	.21	.19			
N	18	16			

The final reading achievement measurement, the C&G, was a test of how much of the program materials, actually presented to the children, had been learned. Table 8.5 presents a summary of data and analyses of the significance of improvement from pre- to post-tests for E and C on the C&G-Reading. In contrast to the MAT and WRA data which were expressed in grade level scores, the C&G results are presented in raw scores corresponding to the number of words actually learned. The mean pre-post C&G-Reading gain scores of 24.16 and 26.00 for E and C respectively were statistically significant beyond the .01 level.

Table 8.5

$\overline{X}$s, SDs and t-tests between Pre- and Post-test C&G Adjusted Scores (Reading) for E and C Groups

		Pre-test	Post-test	gain	t	p
E	$\overline{X}$	19.58	43.74	24.16	5.97	<.01
	SD	26.29	38.59			
	N	19	19			
C	$\overline{X}$	20.50	46.50	26.00	4.90	<.01
	SD	25.76	38.42			
	N	16	16			

It should be noted that the gain score may be presented as a certain percentage of the total number of unknown words to which

Ss were exposed. For example, E's mean pre-post scores of 24.16 words is 25% of the number of unknown words presented. For C, the mean gain score of 26.00 words represented 27%. Table 8.6 again manifests no significant difference (t = .28, p> .05) between the E and C mean gain scores.

Table 8.6

$\overline{X}$s, SDs and t-tests between E and C Pre-Post C&G Adjusted Scores (Reading)

	E	C	diff.	t	p
Mean Pre-Post Diff.	24.16	26.00	1.84	.28	N.S.
SD	17.66	20.52			
N	19	16			

The reading achievement data may be summarized, therefore, as demonstrating statistically significant improvement over all three achievement tests for both the E and C Groups. In no case, however, was there a significant difference between E and C on mean gain scores.

Arithmetic Achievement

Table 8.7 presents a summary of data and analyses of the significantce of improvement from pre- to post-tests for E and C on MAT-Arithmetic. The mean gain of .40 of a grade for E and .26 for C represents a statistically significant improvement beyond the .01 and .02 levels respectively.

Table 8.7

$\overline{X}$s, SDs and t-tests between Pre- and Post-test MAT Grade Level Scores (Arithmetic) for E and C Groups

		Pre-test	Post-test	gain	t	p
E	$\overline{X}$	1.62	2.02	.40	5.48	<.01
	SD	.71	.68			
	N	19	19			
C	$\overline{X}$	1.70	1.96	.26	2.94	<.02
	SD	.58	.63			
	N	16	16			

Table 8.8 presents summary data and evaluates the significance of the difference between the E and C pre-post mean difference scores on MAT-Arithmetic. The obtained t-value of 1.17 (p> .05) illustrates that there was no significant difference between improvement scores for E and C.

Table 8.8

$\overline{X}$s, SDs and t-tests between E and C Pre-Post MAT Grade Level Difference Scores (Arithmetic)

	E	C	diff.	t	p
Mean Pre-Post Diff.	.40	.26	.14	1.17	N.S.
SD	.31	.34			
N	19	16			

Table 8.9 presents a summary of data and analyses of the significance of improvement from pre- to post-tests for E and C on WRA-Arithmetic. In support of the MAT-Arithmetic results, the mean pre-post WRA-Arithmetic gain scores of .38 and .51 for E and C, respectively, represented statistically significant improvement beyond the .01 level. Table8.10, however, manifests no significant difference (t = .79, p >.05) between the E and C WRA-Arithmetic mean gain scores.

Table 8.9

$\overline{X}$s, SDs, and t-tests between Pre- and Post-test WRA Grade Level Scores (Arithmetic) for E and C Groups

		Pre-test	Post-test	gain	t	p
	$\overline{X}$	1.81	2.19	.38	3.11	<.01
E	SD	.59	.54			
	N	18	18			
	$\overline{X}$	1.75	2.26	.51	3.32	<.01
C	SD	.60	.80			
	N	15	15			

Table 8.10

$\bar{X}$s, SDs and t-tests between E and C Pre-Post WRA Grade Level Difference Scores (Arithmetic)

	E	C	diff.	t	p
Mean Pre-Post Diff.	.38	.51	.13	.79	N.S.
SD	.30	.58			
N	18	15			

Table 8.11 presents analyses of the significance of improvement from pre- to post-tests for E and C on the C&G-Arithmetic. The C&G results are presented in raw scores corresponding to the number of discrete arithmetic problems solved. The mean pre-post gain scores of 8.68 and 2.75 for E and C respectively were statistically significant beyond the .01 and .02 levels respectively.

Table 8.11

$\bar{X}$s, SDs and t-tests between Pre- and Post-test C&G Adjusted Scores (Arithmetic) for E and C Groups

		Pre-test	Post-test	gain	t	p
E	$\bar{X}$	34.37	43.05	8.68	4.66	$<.01$
	SD	13.79	9.65			
	N	19	19			
C	$\bar{X}$	38.75	41.50	2.75	2.92	$<.02$
	SD	12.52	11.86			
	N	16	16			

Again, the gain scores may be represented as a certain percentage of the total number of unknown problems to which Ss were exposed. E's mean pre-post gain score of 8.68 problems is 38% of the number of unknown problems presented. For C, the mean gain score of 2.75 problems represented 18%.

In contrast to all the E and C gain score comparisons in both achievement areas cited above, Table 8.12 demonstrates a significant t-value of 2.98 ($p < .05$) between E and C mean gain scores on C&G-Arithmetic.

Table 8.12

$\bar{X}$s, SDs and t-tests between E and C Pre-Post C&G
Adjusted Scores (Arithmetic)

	E	C	diff.	t	p
Mean Pre-Post Diff.	8.68	2.75	5.93	2.98	<.05
SD	7.93	3.03			
N	19	16			

Summarizing the arithmetic achievement data, significant improvement occurred for both the E and C groups over the experimental period, as measured by all three tests. There was no difference between the E and C groups in mean gain scores on either the MAT or the WRA. The C&G, however, indicated that the E group had made a significantly greater gain than the C group.

Retention

In view of the fact that pre- and post-tests were given around each program exposure in the E group and end-of-week tests were given covering all programs used during that week, it was possible to acquire some "retention" data. The word retention is put in quotes advisedly since there is no guarantee that words presented in programs on Monday did not receive some sort of review later in the week. No systematic effort was made to provide such review but this is not the same as saying that it could not have occurred.

Table 8.13 presents means and standard deviations of retention scores. The retention scores represent the Friday end-of-week test scores determined on a base of 12 words (3 programs) minus the immediate post-test scores for the same words at the different retention intervals. An indication of the actual number of words learned and retained over these intervals is provided by the immediate post-test mean score, over all days, of 7.08 as compared to 8.48 for the end-of week score.

An analysis of variance of these data is presented in Table 8.14 and indicates a significant difference between the retention mean scores for the various intervals as well as between subjects.

Table 8.13

"Retention" Data (1-4 Days) for E Group

N = 20

Days	1	2	3	4
$\overline{X}$	2.60	1.70	2.00	3.30
SD	2.16	2.51	1.86	2.37

Table 8.14

Analysis of Variance of Retention Scores (Days 1-4)

Source of Variation	Sum of Square	d.f.	Mean Sq.	F	p
Between Days	30.00	3	10.00	3.16	<.05
Between Subjects	219.20	19	11.54	3.65	<.01
Residual	180.00	57	3.16		
Total	429.20	79			

The specific source of these differences may be determined from an inspection of Table 8.13. It should be noted that all the mean retention scores are positive, indicating that the end-of-week test score was higher than the immediate post-training test.

Although somewhat gross, a long range retention measure was obtained by analyzing the first 72 words taught from the beginning of the semester until the C&G mid-term. The mid-term scores for these 72 words are the number of words retained, from those originally learned, over a period ranging from three weeks to four months. These scores are compared with final exam retention for the same 72 words. The retention span from the mid-term to final exam was three and one-half months.

Table 8.15 shows means and standard deviations for these comparison periods. It is clear that no difference exists for words retained at the final exam period as compared to the mid-term for the 72 words under consideration.

Table 8.15

Comparison of Mean Number of Words Retained on C&G Mid-term and Final (72 words) for E and C Groups

		Mid-term	Final	diff.	t	p
E	Mean	27.68	27.89	.21	.27	N.S.
	SD	24.08	24.30			
	N = 19					
C	Mean	30.06	31.87	1.81	1.10	N.S.
	SD	23.79	23.00			
	N = 16					

Behavior Analyses

All *S*s were rated once a month utilizing the BRBS by two techniques: (1) random ten-minute time-sampling observations by a trained observer; and (2) overall impressions of the teachers. In addition to the scaled ratings of behavior, Progress Notes were tabulated on each *S*, examining in- and out-of-school *negative* behavior separately.

Behavior Rating Basal Scale (time-sampling)

Figure 8.1 presents the mean behavior, for all twelve scales, by E and C groups for the initial (October), and final (April) periods of the school year based on time-sampling observations. December averages are also presented to correspond with the initial teacher ratings which were completed during that month. It may be seen that the pattern of behavioral change is similar for both groups during the first few months, but that the improvement in the E group was superior to the C group particularly during the last part of the school year. t-tests for repeated measures (Oct.-Apr.) demonstrate a statistically significant gain for the E group ($p < .01$) but no significant change for the C group. October ratings between groups show no differences whereas April ratings were statistically significant at the .05 level.

Table 8.16 presents the behavioral averages for E and C groups over the same period by trait scales (1 through 12) with time-sampling observations.

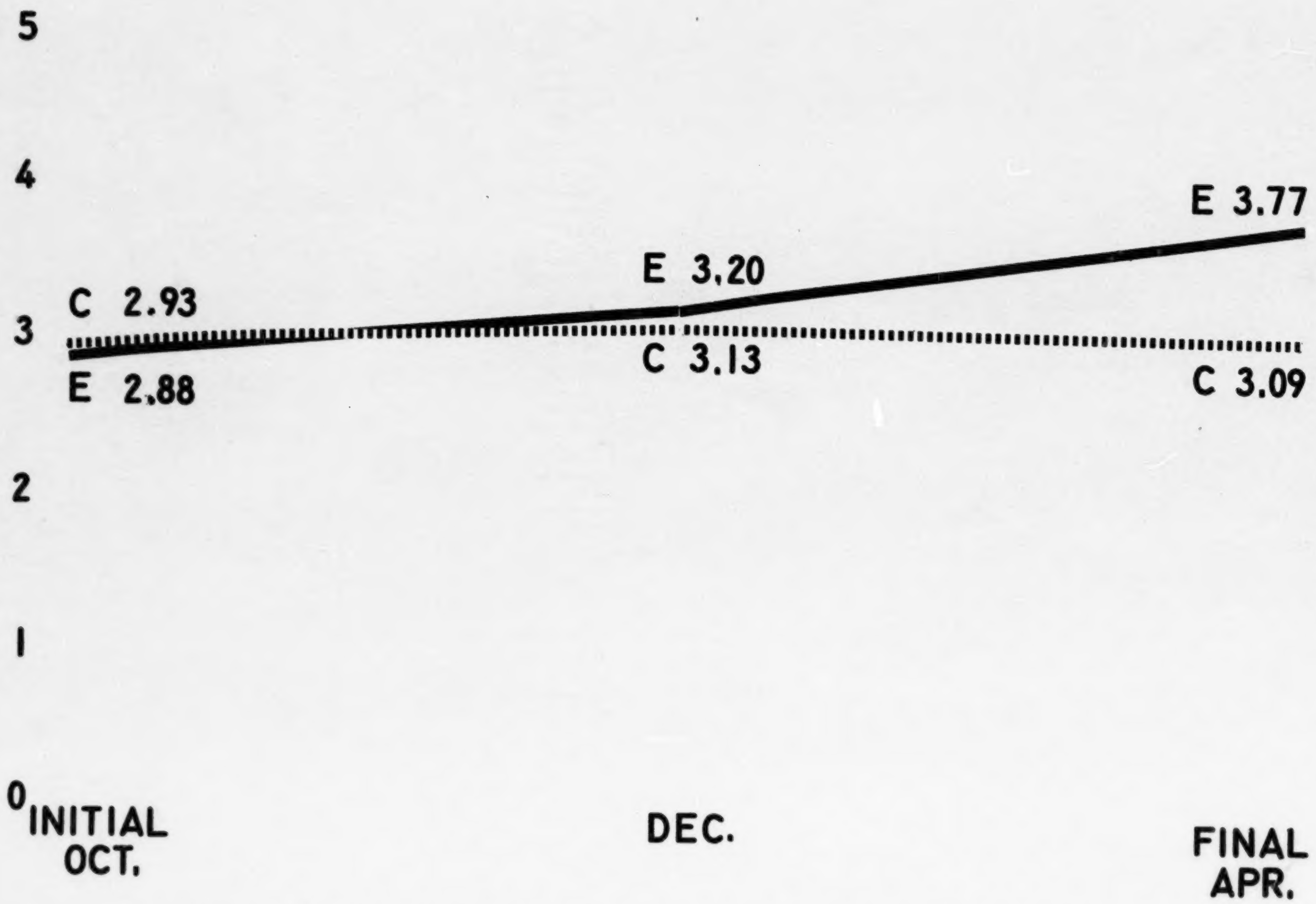


Fig. 8.1. Average Ratings on the BRBS for E and C Groups for October, December and April (Time-Sampling).

Table 8.16

Average Time-Sampling Rating for E and C Groups Oct., Dec., and Apr. by Individual Scales

	Oct.		Dec.		Apr.	
	E	C	E	C	E	C
1. Cooperation	2.7	2.9	3.1	3.1	3.3	3.0
2. Constructive Activities	2.6	2.3	3.2	2.8	3.5	3.1
3. Group Participation	2.5	2.6	2.9	2.9	3.5	2.8
4. Individual Interaction	2.7	2.5	2.9	2.8	3.5	2.9
5. Interest in Learning	2.6	2.8	2.7	2.9	3.6	2.9
6. Independence	3.0	3.1	3.4	3.0	3.7	2.8
7. Persistence	3.1	2.9	3.2	3.2	3.8	3.1
8. Communication & Conversation	2.7	2.9	2.9	3.0	4.0	3.2
9. Freedom from Hyperactivity	3.0	3.1	3.3	3.5	3.8	3.2
10. Freedom from Antisocial	3.2	3.1	3.3	3.3	4.2	3.4
11. Freedom from Irritability	3.3	3.2	3.7	3.4	4.1	3.4
12. Frustration Tolerance	3.1	3.4	3.8	3.6	4.2	3.3
Mean	2.88	2.93	3.20	3.13	3.77	3.09

Again it may be seen that the superiority of the E group reaches its peak at the end of the school year to the point that they excel the C group on all traits.

Behavior Rating Basal Scale (teacher observations)

Since the teachers did not begin their monthly ratings on the BRBS until December, 1962, the data following represents initial (December) and final (April) ratings for E and C groups.

Figure 8.2 represents the mean behavior of E and C groups for initial and final teacher ratings, combining all twelve scales. It may be noted that no major changes were observed for either group; however, the E group demonstrated some gain whereas the C group showed none. A series of t-tests showed no significant differences between December and April ratings for either group and no differences in initial and final ratings between groups.

Table 8.17 presents the behavioral averages for E and C groups on initial and final teacher ratings by individual trait scales (1 through 12).

Table 8.17

Average Ratings on BRBS for E and C Groups, Initial and Final Teachers' Ratings, by Individual Scales

	Initial		Final	
	E	C	E	C
1. Cooperation	3.8	3.3	3.8	3.3
2. Constructive Activities	2.6	2.6	2.6	2.8
3. Group Participation	3.2	2.6	3.3	2.4
4. Individual Interaction	2.7	2.9	2.7	2.4
5. Interest in Learning	3.2	3.1	3.5	3.4
6. Independence	2.8	2.2	3.1	2.6
7. Persistence	2.9	2.9	3.2	2.9
8. Communication and Conversation	3.2	3.1	3.3	2.8
9. Freedom from Hyperactivity	3.0	2.8	3.1	2.9
10. Freedom from Antisocial	3.9	3.5	4.3	2.9
11. Freedom from Irritability	3.6	3.1	3.9	2.8
12. Frustration Tolerance	2.8	2.7	3.2	3.0
Mean	3.14	2.90	3.33	2.85

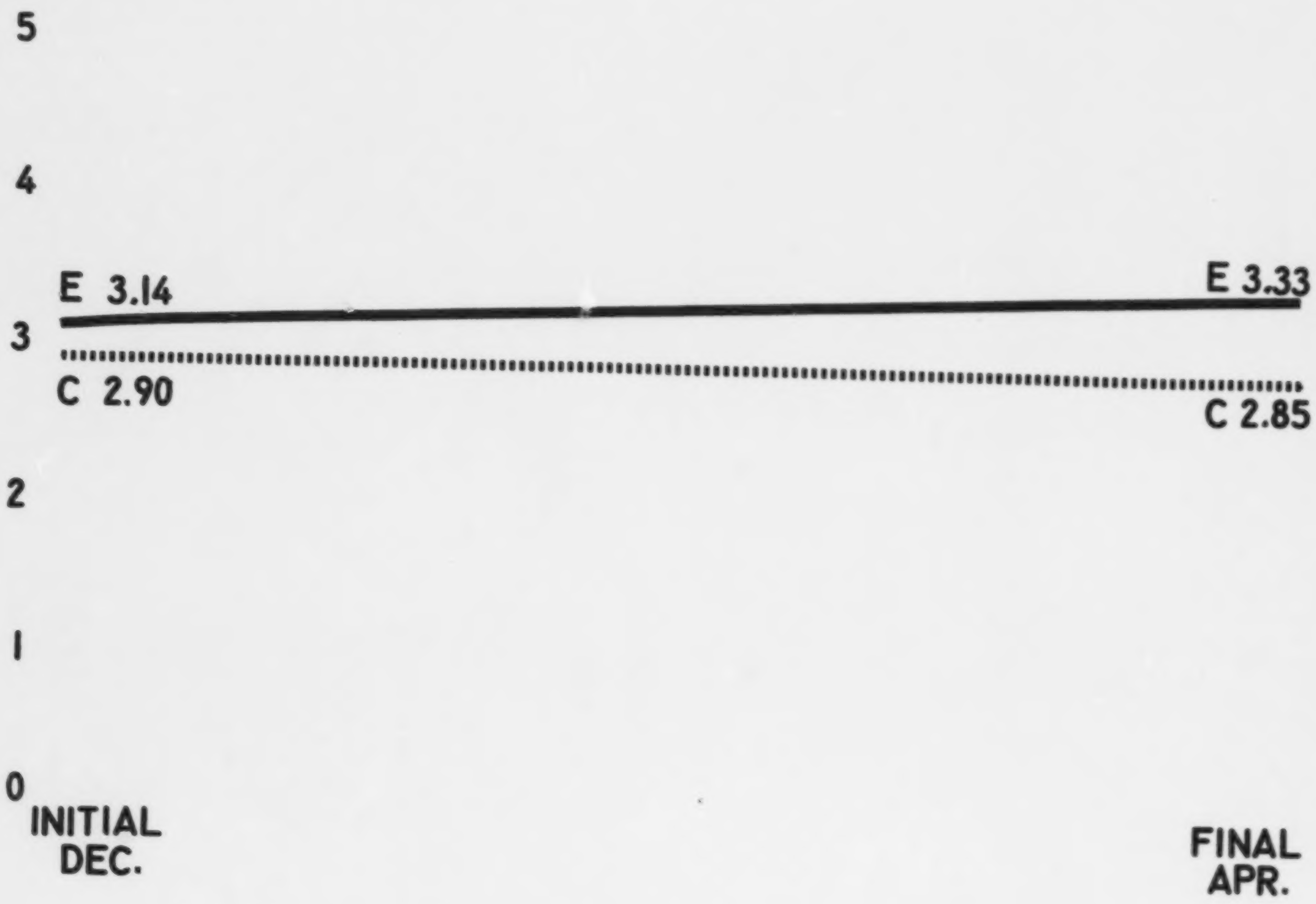


Fig. 8.2. Average Ratings on the BRBS for E and C Groups for December and April (Teacher Ratings).

Summarizing the results on the BRBS, it may be seen that the E and C groups demonstrated similar improvement from October to December ratings by time-sampling observations. From December to April ratings, the time-sampling and teacher observations confirm an improvement in behavior for the E group and relatively no change for the C group. These changes were statistically significant on the time-sampling but not demonstrable via teacher ratings.

Progress Notes

Negative behaviors reported in the form of Progress Notes were tabulated for E and C groups at the beginning (October-November) and end (March-April) of the school year. School and out-of-school Progress Notes are reported separately.

Figures 8.3 and 8.4 present graphically the number of negative behaviors recorded for E and C groups, initial and final, from school and out-of-school sources.

An examination of these data shows no demonstrable change in negative behaviors from initial to final scores for the E group in the number of school Progress Notes but a large increase in negative reports for the C group. Out-of-school sources reported significantly fewer negative behaviors at the close of the school year for the E group but relatively little discrepancy between beginning and end of school year for the C group. A statistical analysis of these data was abandoned in favor of graphic representation, as the "strength" of each Progress Note would have to be determined subjectively; that is, rather than mere enumeration of negative behaviors reported, some quantitative system would necessarily have been devised to account for the difference between serious and trifling behavioral offenses.

Summarizing the Progress Notes data, it may be seen that, in agreement with the BRBS results, the teaching machine experience apparently exerted a settling influence upon the E group which pervaded out-of-school activity as well as in-school behavior. The positive change in behavior for those Ss exposed to programmed instruction is supported by a recently completed study by McKee, Rickard and Masterson (1963). Their results demonstrate a dramatic positive change in behavior for a group of Ss, selected on the basis of average intelligence, academic failure, and overt undesirable classroom behaviors, who were exposed to programmed instruction in English. Scholastic achievement was relatively unaffected in spite of the behavioral change.

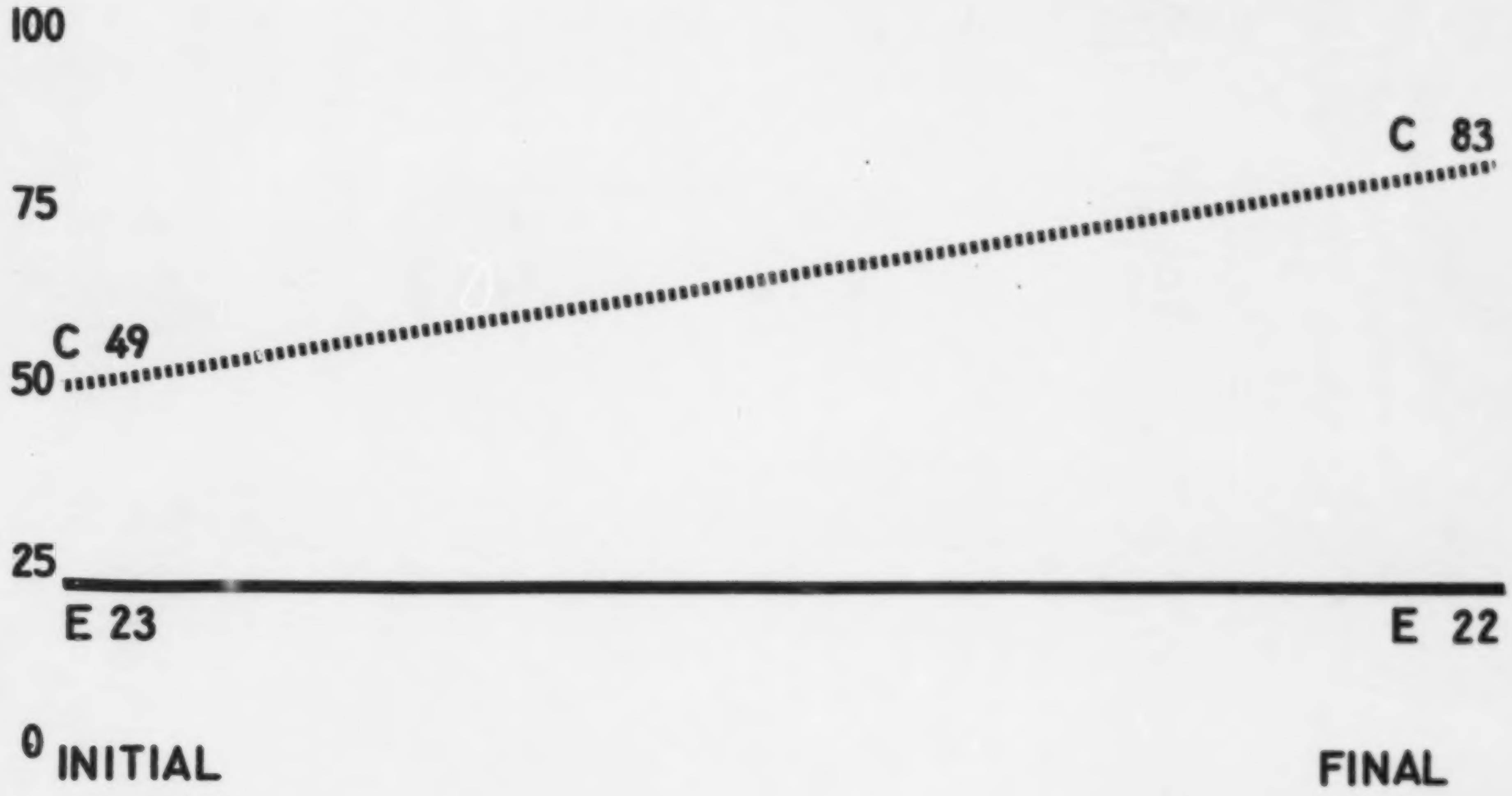


Fig. 8.3. Progress Notes (negative) for E and C Groups, Initial and Final, from School Sources.

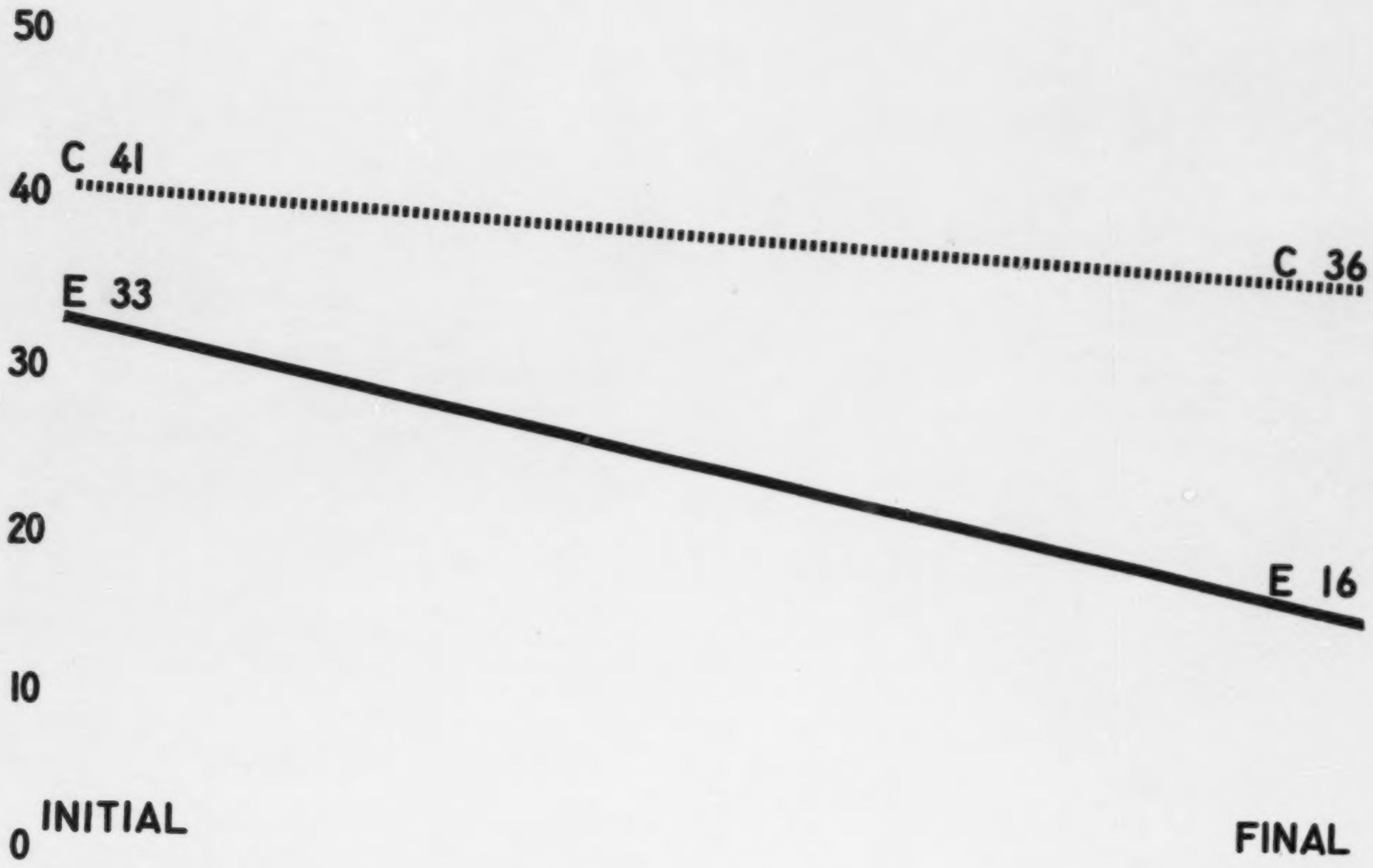


Fig. 8.4. Progress Notes (negative) for E and C Groups, Initial and Final, from Out-of-School Sources.

Chapter 9

Discussion

For purposes of organization and clarity of exposition, the achievement, retention, and behavioral data will be discussed separately.

Achievement

With the exception of one statistically significant difference between the performance of the E and C groups on one arithmetic achievement test, any objective perusal of the tables in the Results Chapter summarizing the achievement data must force the sobering generality that, within the context of this experiment, there was no apparent difference between the performance of machine and non-machine groups. These findings are generally confirmatory of what might be described as the modal result in comparisons of programmed versus conventional instruction reviewed elsewhere in the literature (Silberman, 1962).

Regarding arithmetic achievement specifically, the greater gains made in this area, as compared to reading, by both groups, suggest two possible explanations: (1) the material lends itself to more effective instruction; or (2) the special capabilities and interests of the the retarded learner are more closely attuned to this skill area. In addition, the fact that the only significant difference between machine and non-machine groups occurred in arithmetic performance confirms the subjective observations of programmers that the more clearly hierarchical structure of arithmetic makes it more readily adaptable to the programming process.

Although the results demonstrate consistent, significant gains in reading and arithmetic on all achievement tests, this improvement must not be considered educationally dramatic. A comparison of the grade level achievement gains of E and C groups with the remainder of the school population from which these samples were drawn is summarized in Tables 9.1 and 9.2.

As this tabular material indicates, neither the E nor C groups differed significantly from the remainder of the school population in the amount of improvement shown during the school year as measured by the WRA. These findings must be qualified, however, by the fact that both the E and C groups were significantly younger and lower in IQ than the remaining school population. An additional factor to consider is that the interval between pre- and post-testing was approximately one month shorter for the E and C groups than for the remaining pupils. Thus, it may be argued that under more comparable conditions of sample and testing interval, the E and C scores may have exceeded those of the non-project pupils.

Table 9.1

Comparison of Reading Difference Scores (WRA) from Pre- to Post-tests for E and C Groups Versus the Remaining School Population

	N	$\bar{X}$	SD	t	p
E	18	.24	.21		
				.085	N.S.
Remainder	91	.25	.34		
				.910	N.S.
C	16	.34	.39		

Table 9.2

Comparison of Arithmetic Difference Scores (WRA) from Pre- to Post-tests for E and C Groups Versus the Remaining School Population

	N	$\bar{X}$	SD	t	p
E	18	.33	.31		
				.022	N.S.
Remainder	91	.38	.30		
				.813	N.S.
C	15	.51	.57		

Retention

In attempting to explain the apparent "retention gain" in the one to four day retention measures, the reader is reminded of the uncontrolled review element via non-machine seat work and/or incidental classroom discussion. With the exception of the one day retention score, which is second only to the four day score, the remaining data would appear to confirm this speculation. That is, the longer the retention interval, the greater the opportunity for random review, and subsequent improved performance. The higher retention scores for the four and one day intervals could also be interpreted in terms of an overlay primacy-recency effect.

The results of the longer range retention measure show no significant differences in the number of words retained over a three and a half month period for either the E or C Groups. This finding is generally supportive of other observations in the literature (Ellis, 1963) that long term memory is unimpaired in the mentally retarded.

As in any type of molar research which employs the complex and contaminated classroom environment as its setting in an effort to generate data which might be transferable to similar settings, a number of mitigating factors have been identified which affected the experimental opeation and may have affected the conclusions drawn from it.

It is conceivable, for example, that the design of this study which compared regular instruction to regular plus machine instruction diluted the effect of machine instruction. Of course, an assumption of independent and summative effects of these two variables must underlie this speculation.

Part of the design of this study was to hold constant the rate at which both groups progressed through the material. The rationale underlying this restriction was that the range of material which could be covered was not a primary consideration in teaching the mentally retarded but that the quantity of material learned and retained, per equal amounts of instructional time, was a more pertinent issue. Nevertheless, since the mettle of programmed instruction has been frequently demonstrated in terms of the speed with which given courses of study could be completed (Calvin, 1960), it is evident that the particular design of this study suppressed predictable time benefits.

It should be noted at this point that some difficulty was experienced in controlling the pace of instruction. Early in the study, one teacher, in her control class function, was discovered going beyond the material alloted to a particular week. This, in spite of the fact, that the same individual was teaching a comparable experimental class during another part of the day; an arrangement designed to diminish any competitive impulses. This situation was very quickly remedied.

A cogent criticism of this study relates to the nature of program development and the consequent quality of programs. As described in Chapters 5 and 6, both the extensive reading and arithmetic programs were developed by educational specialists who were relatively unsophisticated in the art of programming. More important, however, due to the large quantities of materials required and the limited time available for preparing these

materials, the programs were not subjected to recommended evaluation procedures. In effect, a "good teacher" was programmed, but without the benefit of error rate analyses, successive modifications, and other features of sound program construction.

The relatively high starting levels in arithmetic of both the E and C groups, as reflected by the C&G, and the small gains evidenced at the final evaluation period can be explained in terms of a ceiling effect imposed by time limitations. Since all Ss were required to start at the very beginning of the program, much time was spent in exposing some Ss to material already known, thereby sharply limiting the amount of exposure time for new materials.

In any research study which reports essentially negative findings accompanied by a series of possible mitigating factors which may have precluded a fair test of the experimental techniques, there is a question as to whether the findings may be considered negative or are simply indeterminate. In effect, a post hoc judgment must be made as to whether any one or all of the contaminating factors described above (limited machine exposure, controlled pace, program quality, high starting levels in arithmetic) are of sufficient moment to consider the experiment abortive or a reasonably fair test in the variable contaminating atmosphere of a "real-life" classroom. Perhaps, the classroom in which this evaluation took place was bigger than life in that equipment was diligently maintained, teachers assisted in the operation of the machines, and programs made easily available. Each reader, on the basis of his experience and/or scientific judgment, must conclude for himself the reliability of this negative report at least as it pertains to the achievement variables. Future research will serve as epilogue.

Behavior

In order to obtain a relatively objective measure of behavioral change in the E and C groups over the school year, a modified version of the Behavior Rating Basal Scale (BRBS), developed by Dr. Harriet Blodgett of Minneapolis, Minnesota, was utilized by two distinct methods: (1) a time-sampling technique, whereby each S was rated on a five-point scale over twelve traits (ten consecutive minutes of observation per child on randomly selected days of the week) averaging one complete evaluation per month; and (2) monthly assessments of each child on all traits by the project teachers. These measures afforded two ratings per child on all behavioral traits for each month the school-phase of the program was in operation. "The attempt to make use of behavior ratings of various sorts is not a new one, and is subject to many sources of error" (Blodgett, 1960):

limited framework of observers, halo effect, discrepancies in steps intra- and inter-trait, the inherent difficulties of quantification and the variability of inter-observer reliability. Despite these shortcomings, it was felt that these ratings would add pertinent information to the evaluation of self-teaching devices in classrooms for the mentally retarded.

The results of the time-sampling and overall ratings were analyzed separately. For each analysis, the ratings at the initial evaluation were compared to the final ratings at the end of the school year. Ratings were limited to actual classroom behaviors. In personal correspondence with Dr. Blodgett, the author of the scale, it was cautioned that difficulty and dissatisfaction were noted with scale nos. 8 and 9. For the purpose of this project, scale nos. 8 and 9 were combined and scale no. 14 eliminated from the ratings. In essence then, with the revision, scale no. 8 became Conversation and Communication, a combination of the original scale nos. 8 and 9, and the new numbering beyond this point became no. 9 for the original no. 10, no. 10 for no. 11, no. 11 for no. 12, and no. 12 for no. 13. The original and revised scales may be seen in Appendix D.

Time Sampling

Random selection of the order of Ss in E and C groups for time-sampling observation provided ratings which insured a diverse sample of S's behavior in many stages of his daily and weekly program. This afforded insurance against observations of a specific S, continually, for one specific portion of the school day. Chapter 8 demonstrates superior gains on all traits by the E group and a statistically significant mean gain.

Immediately, the question of "Hawthorne Effect" is raised. But for this particular set of samples, this effect is compensated for in at least two respects: (1) the bulk of both project groups, E and C, were Ss selected from another State institution--a "graduation" which is generally considered beneficial by residents of both institutions; and (2) the E and C groups were exposed to an equal amount of pre- and post-testing, time-sampling observations and other forms of individual attention--sufficient reason to at least partially wash-out the "Hawthorne Effect." The improvement in behavior, then, might be considered a "real" change. Evidently, the teaching machine and its accompanying programs produced a "settling" effect on these mentally retarded students.

Among a host of possible explanations for these changes, at least three factors loom large.

1. The machines are "self-paced" without overt pressures exerted by the teacher, reducing S's frustration.
2. Immediate feedback, in the form of red and green lights, allow for consistent reinforcement for the teaching machine students.
3. The "pin-ball" effect or novelty of the machine itself may have motivated the E students, increasing attention and interest.

If these factors were not sufficient to improve learning and retention as measured by most of the evaluation instruments, they may have operated to improve the classroom behaviors of the Ss assigned to the machine groups by reducing frustration and maximizing attention.

Teacher observations

The results of teachers' ratings on the BRBS are not dissimilar to the time-sampling observations. The trend in the initial to final ratings for both groups in the former's reports are in the same direction, although not statistically significant, as were the observations by time-sampling. Consistency between observational approaches is further verified by the superiority of the E group on all scales, save one (no. 2), on the final teachers' ratings. The relatively higher initial ratings by teachers may be explained by the time-interval between the two initial ratings (October-time sampling versus December-teacher rating); hence, a more accurate comparison between observational techniques would entail the examination of the separate December ratings--both completed after "adjustment" of the project Ss had been partially completed.

Even though the groups are not similar, a comparison of BRBS scores for E and C groups with those reported for the Sheltering Arms (a day school and research program for mentally retarded children) groups was deemed pertinent. In the "Five year report of the Sheltering Arms," Blodgett (1960), analyzed the results of the BRBS on five separate groups which included three trainable and two educable classes separated by CA groupings. Over the five year period, 97 children were served by the program: 59 trainables, approximately 30-50 IQ; and 38 educables, 50 to 80 IQ. Table 9.3 gives the final mean rankings of the young and older educables representing the Sheltering Arms program and the E and C final averages on the 12 scales of the modified BRBS (time sampling).

Comparing the overall average ranks on all traits it may be seen that the E group's mean of 3.77 measured close to the combined mean of the Sheltering Arms' young and older educables (3.69), but the C group measured considerably lower than either educable group. In fact, the combined average rating of the three

Table 9.3

Final ratings of E and C Groups Compared to Sheltering Arms Younger and Older Educable groups

	1	2	3	4	5	6	7	8	9	10	11	12	Mean
E	3.3	3.5	3.5	3.5	3.6	3.7	3.8	4.0	3.8	4.2	4.1	4.2	3.77
C	3.0	3.1	2.8	2.9	2.9	2.8	3.1	3.2	3.2	3.4	3.4	3.3	3.09
Young Educ.	3.5	3.4	3.3	3.4	3.5	3.9	3.3	4.2	3.2	3.7	3.3	3.2	3.49
Older Educ.	3.9	3.8	3.5	3.8	3.6	4.3	3.7	4.5	4.2	4.1	3.8	3.4	3.88

Trainable groups (not included in the Table) of the Sheltering Arms population, over all traits, was reported as 3.07--almost identical to the Johnstone C group (3.09).

After a perusal of individual scale comparisons of the Johnstone and Sheltering Arms populations on the BRBS, of particular interest is the superiority of the latter groups on the Independence and Communication-Conversation scales, numbers 6 and 8 respectively, and the only striking superiority of the E group on scale 12, Frustration Tolerance. Since the C group showed no similar superiority, the generalization formerly made with regard to the E and C BRBS and Progress Notes comparisons is supported with the additional comparison between E and the Educable groups of Sheltering Arms; that is, that the exposure to teaching machine, programmed instruction apparently exerts a positive influence on the behavior of mental retardates. This generalization is further supported by the generally high ranking obtained by the E group on the other "emotional" scales, i.e., 9, 10, and 11.

Progress Notes

The analyses of the number of Progress Notes reported for E and C students at the beginning and end of the school year supports the ratings of the BRBS, in spite of the fact that the Progress Notes are indicative of in- and out-of-school behaviors while the BRBS ratings relate to classroom behaviors only. It may be assumed on the basis of the out-of-school reports, which are essentially non-project oriented (and therefore, perhaps, somewhat less colored experimentally), that improvement in behavior which might be attributed to classroom, machine exposure was transferred to cottage and other non-school behaviors by the E group.

Results show essentially no change for the C group in the number of progress notes reported at the beginning and end of the school year for out-of-school, negative behaviors but a dramatic decrease of such reports for the E group. School progress notes show little change for the E group from beginning to end of the school year but a significant increase of negative reports for the C group over the same period. In light of these data, future investigators and practitioners might well consider the potential of this form of instruction in terms of its therapeutic as well as its acquisitive benefits.

Chapter 10

Summary and Conclusions

This portion of the study was undertaken to compare the achievement of two equated groups of educable mentally retarded young adolescents in primary reading and arithmetic. One group was exposed to teaching machine-presented, programmed instruction plus regular instruction while the second group was taught the same material by "traditional" special class methods.

The sample consisted of 19 Ss in the teaching machine group with a mean CA of 14.1 and a mean IQ of 54.3. The control group was comprised of 17 Ss whose mean CA and IQ were 14.3 and 54.2 respectively. With the exception of two females in each group, the remaining Ss were males.

The battery of achievement tests used to evaluate progress was administered at the beginning and end of the school year. This battery of tests included the Metropolitan Achievement Test, the Wide Range Achievement Test, and the C&G - a test specially constructed to measure acquisition of program materials.

Measures of change in behavior during the experimental period were obtained by parallel teacher ratings and time sampling observations using the Behavior Rating Basal Scale. Negative in- and out-of-school Progress Notes were also employed at the beginning and end of the school year to assess behavioral changes.

Teachers of the machine and non-machine groups were instructed to maintain the same academic pace with their experimental and control students so that the material covered by both groups was equivalent. The experimental classrooms were provided with assistance by older residents of the Johnstone Center who monitored the machines and assumed the responsibility of loading and unloading the programmed material. Teachers were therefore afforded sufficient time to pre- and post-test each subject before and after his machine experience. End of the week retesting of machine-exposed material provided for short-term retention analysis and the mid-term to final testing of programmed material allowed for a long-term retention evaluation. To insure minimum teacher bias, the two project teachers exchanged their classroom assignments at mid-year.

The results of the analysis of the achievement data were as follows:

1. Both the machine and non-machine groups improved significantly over the school year in reading and arithmetic as

measured by the Metropolitan Achievement Test, the Wide Range Achievement Test and the C&G Test.

2. There were no significant differences, however, between the improvement scores of the machine and non-machine groups on any of the achievement scales listed above with the exception of the C&G Test-Arithmetic. On this test, the pre- to post-test gain scores of the machine group were significantly larger than those of the non-machine group.

Pre- and post-tests as well as end of the week retests given to the experimental group on machine-exposed programs enabled the investigators to derive rather contaminated one, two, three and four day retention scores. The contamination, resulting from the possibility of uncontrolled review between initial program exposure and end-of-week test, was apparently manifested in consistent retention gains for all four retention intervals. With the exception of day one, there appeared to be a direct relationship between the size of the retention gain and the length of the retention interval.

A long term retention measure (three and one-half months) available for both the machine and non-machine groups indicated no significant difference, for either group, between a sample of words known at the mid-term and readministered in the final exam. The absence of a retention loss over this period must be qualified by the statement that, although the words were not specifically taught again, it was not possible to restrict their informal and indirect reoccurrence.

A compariosn of the two groups on the Behavior Rating Basal Scale (BRBS) demonstrated statistically significant improvement favoring the machine group with the time sampling observations. Results were in the same direction, although not statistically significant, when teachers' ratings were analyzed.

Although statistical tests of significance were not employed due to a problem of equivalence of units of data, the tabulation of Progress Notes for the two groups supported the BRBS findings. There was no change in the school behavior of the machine group during the school year whereas the negative school behavior of the non-machine group increased sharply. In out-of-school behavior, there was no change for the non-machine group but significantly fewer behavior problems reported for the machine group.

With the exception of the positive result on one arithmetic measure, the findings of this study in terms of the effectiveness of machine teaching in facilitating the development of primary reading and arithmetic skills are essentially negative. These results are discussed in terms of a number of possible mitigating factors such as: (1) limited time for machine exposure in the machine groups; (2) the design of the study which controlled the pace of instruction in the two groups; and (3) questionable quality of programs. It should be noted, however, that these results are not atypical of findings obtained by similar studies reported in the literature.

The positive findings in relation to the behavior variables are interpreted in terms of the "therapeutic" effects on long-suffering mentally retarded school children of machine instruction which allows self-pacing free from teacher pressures, a preponderance of success experience during training, immediate feedback, the attention-compelling "pin-ball" novelty of the devices, and the anxiety-allaying impersonal approach to instruction.

By any criteria, this study must be considered a pioneering effort in the application of programmed instruction to the mentally retarded. Continuing improvements in hardware and programs, as well as demands by educators for information, will undoubtedly entice other investigators into the comparison of methods attempted in this report. More important, however, educational psychologists now find themselves on the brink of an era which will witness the development of a true educational technology. Instructional systems are now available that can create the reliable and replicable stimulus environments for learning that sophisticated psychological theory demands. Profitable research in this area, therefore, rests not with the comparison of one grossly defined instructional method with another even more poorly defined one, but rather, research in programmed instruction which seems to fulfill its promise when it employs the rigor and controls at its disposal to achieve a better understanding of the psychological properties of school tasks as they interact with the abilities and disabilities of individual learners.

References

Belcastro, F. Programmed learning: relative effectiveness of four techniques of programming the addition and subtraction axioms of algebra. Unpublished doctoral dissertation. Univer. of Pittsburg, 1961. (Abstract in AV Communication Rev., 10, No. 6, p. 356).

Betts, E. A. Developing basic reading skills: through effective class organization. Education, 1958, 78, 561-76.

Blackman, L. S., & Holden, E. A., jr. Support versus non-support in an auto-instructional word program for educable retardates. Amer. J. ment. Defic., 1963, 67, 592-600.

Blodgett, Harriet E. Five year report of The Sheltering Arms. A day school and research program for mentally retarded children in cooperation with the Minneapolis Public Schools. Sheltering Arms, Minneapolis, Minn., Sept. 1960.

Bond, G. L., & Tinker, M. A. Reading difficulties, their diagnosis and correction. New York: Appleton-Century-Croft, 1957.

Borreca, F., Buger, R., Goldstein, I., & Simches, R. A functional core vocabulary for slow learners. Amer. J. of ment. Defic., 1953, 58, 273-300.

Brueckner, L. J., & Bond, G. L. The diagnosis and treatment of learning difficulties. New York: Appleton-Century-Croft, 1955.

Bugby, J. L., & Mann, L. The TMI self-tutoring program in spelling compared with teacher and flashcard taught programs. J. educ. Res., 1962, 55, 585-586.

Calvin, A. D. A demonstration class using teaching machines for ninth grade algebra. Unpublished paper, Hollins College, Virginia, 1960.

Calvin, A. D. A report in retention of programmed material. Unpublished paper, Hollins College, Virginia, 1961.

Clymer, T. The real frontier in reading research. Reading Teacher, 1958, 12, 92-97.

Eigen, L. D., & Komoski, K. P. Research summary No. 1, New York. Collegiate School Automated Teaching Project, June, 1960.

Eigen, L. D., Filep, R. T., Goldstein, L. S., & Angalet, B. W. A comparison of three modes of presenting a programmed instruction sequence. New York, The Center for Programmed Instruction, Jan., 1962.

Ellis, N. R. The stimulus trace and behavioral inadequacy. In N. R. Ellis (Ed.) *Handbook of mental deficiency.* New York: McGraw-Hill, 1963.

Ellson, D. G. Programmed teaching and elementary reading-a progress report. Paper presented at the Great Lakes Regional meeting of A.A.M.D. Bloomington: Indiana Univer., 1961 pp. 14 (Mimeo).

Galanter, E. (Ed.) *Automatic teaching: the state of the art.* New York: Wiley, 1959.

Gates, A. I. *The improvement of reading, a program of diagnostic and remedial methods.* Third edition. New York: Macmillan, 1947.

Gotkin, L. G., & Goldstein, L. S. Programmed instruction for the younger learner: a comparison of two presentation modes in two environments. Paper presented at the American Educational Research Assoc., Atlantic City, Feb., 1962.

Gray, W. S. *On their own in reading.* Revised edition. Chicago: Scott, Foresman and Company, 1960.

Gray, W. S. Summary of reading investigations, July, 1957 to June, 1958. *J. educ. Res.*, 1959, *52*, 203-221.

Groff, P. J. The problem of vocabulary load in individualized reading. *The Reading Teacher*, 1961, *14*, 195-199.

Harris, A. J. *Effective teaching of reading.* New York: David McKay, 1962.

Harris, A. J. *How to improve reading ability.* New York: Longmans Green, 1940.

Hart, R. H. The effectiveness of an approach to the problem of varying abilities in teaching reading. *J. educ. Res.*, 1959, 52, 228-231.

Hawker, J. R., Geertz, V. W., & Shrago, M. Prompting and confirmation in sight vocabulary learning by retardates. Kansas Neurological Institute, July, 1963.

Hegge, T. G., Kirk, S. A., & Kirk, Winifred D. Remedial reading drills. Ann Arbor, Michigan: George Wahr Publishing Co., 1955.

Hively, W. An explanatory investigation of an apparatus for studying and teaching visual discrimination, using preschool children. In A.A. Lumsdaine and R. Glaser (Eds.) Teaching machines and programmed learning. Washington, D.C.: NEA, 1960.

Hosmer, C. L., & Nolan, J. A. Time saved by a tryout of automatic tutoring. Automated Teach. Bull., 1960, 1, 17-18.

Hough, J. B. Research vindication for teaching machines. Phi Delta Kappan, 1962, 42, 240-242.

Hutt, M. L., & Gibby, R. G. The mentally retarded child. Boston: Allyn and Bacon, 1958.

Keislar, E. R. The development of understanding in arithmetic by a teaching machine. J. educ. Psychol., 1959, 50, 247-253.

Klausmier, H. J., Lehmann, I. J., & Beehan, A. Relationships among physical, mental and achievement measures in children of low, average and high intelligence. Amer. J. ment. Defic., 1959, 63, 647-656.

Komoski, K. P. Origin of collegiate school automated teaching project. Unpublished report, Collegiate School, New York, 1960.

Lumsdaine, A. A., & Glaser, R. (Eds.) Teaching machines and programmed learning. Washington, D.C.: NEA, 1960.

Malpass, L. F. et.al. Comparisons of automated teaching programs for retarded children. Project submitted to U.S.O.E. University of South Florida, 1960.

Malpass, L. F. et.al. Comparison of two automated teaching machine procedures for retarded children. Progress Report No. 1. University of South Florida, 1962a.

Malpass, L. F. et.al. Comparison of two automated teaching machine procedures for retarded children. Progress Report No. 2. University of South Florida, 1962b.

McKee, J. M., Richard, H. C., & Masterson, J. "Programmed Learning: An Approach to The Modification of Undersirable Behavior." Unpublished manuscript, 1963.

Meier, C. Effect of prizes in increasing the word learning of subnormal children. *Train. Sch. Bull.*, 1935, *32*, 146-157.

Meyer, Susan. A program in elementary arithmetic: present and future. In E. Galanter (Ed.) *Automatic teaching: the state of the art.* New York: Wiley, 1959.

Moran, R. E. Levels of attainment of educable subnormal adolescents. *Brit. J. educ. Psychol.*, 1960, *30*, 201-210.

Morgan, F. F. Jr., & Strucker, G. E. The Joplin Plan of reading versus a traditional method. *J. educ. Psychol.*, 1960, *51*, 69-73.

Osler, Sonia F. Apparatus for the study of discrimination and concept formation. *Amer. J. Psychol.*, 1960, *73*, 627-629.

Page, E. B. Teacher comments and student performance: a 74 classroom experiment in school motivation. *J. educ. Psychol.*, 1958, *49*, 173-181.

Porter, D. A critical review of a portion of the literature on teaching devices. *Harvard Educ. Rev.*, 1957, *27*, 126-147.

Porter, D. Some effects of year long teaching machine instruction in automatic teaching. In E. Galanter (Editor). *Automated teaching: the state of the art.* New York: Wiley, 1959.

Raygar, A., & Wark, D. Reading skills project. University of Minnesota. Abstracted in AID, March 1962.

Ryans, D. G. *Characteristics of teachers.* Washington, D.C.: American Council on Education, 1960.

Shay, C. B. Relationship of intelligence to step size on a teaching machine program. *J. educ. Psychol.*, 1960, *52*, 98-103.

Silberman, H. Self-teaching devices and programmed materials. *Rev. educ. Res.*, 1962, *32*, 179-193.

Smith, E. A., & Quackenbush, J. Devereux teaching aids in presenting elementary mathematics in a special education setting. *Psychol. Reports,* 1960, *7*, 333-336.

Smith, W., & Moore, J. W. Size of step and advancement in programmed spelling. Bucknell Univer., September, 1961.

Sprague, R. L., & Binder, A. Automated arithmetic instruction for the retarded. Progress Report, PHS Grant M-5647 (A), 1962.

Stolurow, L. M. Programmed instruction for the mentally retarded. Rev. educ. Res., 1963, 33, 126-136.

Stolurow, L. M. Teaching machines and special education. Educ. & Psychol. Measmt., 1960, 20, 429-448.

Stolurow, L. M., & Lippert, H. Prompting confirmation, and vanishing in the teaching of a sight vocabulary. Technical Report, Office of Education, Cooperative Research Project Contract No. SAE 8370, U.S. Dept. of Health, Education and Welfare, 1962.

Strang, Ruth., McCullough, Constance M., & Traxler, A. A. Problems in the Improvement of Reading. Second edition, New York: McGraw-Hill, 1955.

Traxler, A. S. Recent findings and trends in research on reading. Reading Teacher, 1959, 13, 90-99.

Warburton, F. W. Educational psychology. Ann. Rev. Psychol., 1962, 13, 371-414.

Wechkin, S. Word learning in an automated teaching situation as a function of display condition. J. educ. Psychol., 1962, 53, 65-69.

Part II

Psychological Research Background

Chapter 11

Some Variables in Automated Teaching

Belver C. Griffith[1]

Whenever a new technical development appears, there is the danger that a preoccupation with its immediate application may preclude the type of systematic investigation that leads to further development. In automated teaching, there is some hint of this danger in the relatively rapid development of both devices and programs. This development has occurred in spite of a lack of research bearing directly on problems of automated teaching. Although related work has been carried out, no single group of investigators has consistently worked with the appropriate combinations of subjects and materials in closely controlled training situations. Thus, while education has been concerned with the proper range of subjects and materials, it has not worked in terms of well-defined trials and responses. Research in human learning has usually dealt with single-response trials; however, it has usually avoided the combinations of subjects and materials most directly relevant to educational problems.

The main source of confidence spurring the practical application of techniques has been Skinner, whose earlier work was neither with the appropriate materials, subjects nor, if one agrees with Zeaman's analysis (1959), training situation. This confidence appears based, partially on Skinner's assumption that his earlier work on free operant conditioning is fundamental to automated teaching and partially on his rather high optimism with regard to present states of knowledge. For example, Skinner (1958) seems to assure readers that "the special problems raised by verbal behavior" can be shown to yield readily to the type of analysis he had made of animal behavior. Aside from whether or not Skinner's point of view is eventually proven true, it must seem somewhat premature to other students of verbal behavior.

While a number of research workers appear to share Skinner's confidence and move directly into the programming of materials for classroom use, others, more impressed by the complexity of problems associated with automated teaching, have not. Among them, Gagne and Bolles (1959), Lumsdaine (1960) and Stolurow (1960) have undertaken to outline systematic approaches to research problems. These papers were not concerned with some of the simplest variables, such as timing and reward contingencies that should operate in the training of simple language and number skills.

---

[1] Now Associate Director, Project on Scientifc Information Exchange in Psychology, American Psychological Association.

To supplement the earlier papers, this paper will attempt to indicate the major variables that should affect the learning of simple materials and to consider possible research strategies. Paired-associates learning has been taken as an implicit paradigm for training since, in general, much primary school training is intended to teach the child to make a specific response, such as saying a word or writing a numeral, to a specific stimulus. In order, the components of a trial will be enumerated, and variables, pertaining to a single trial and to combining trials into series (programming), will be discussed. Finally, transfer from the training situation to criterial responses will be discussed.

Single Trial

Components

Prior to the beginning of a trial, it is assumed that the subject has received sufficient instructions to respond over a series of trials. The instructions may, of course, communicate some content, necessarily limited in difficulty. The trial may include the following (the abbreviation to be used is indicated in parenthesis):

1. Stimulus (S). A physical event which initiates the trial and specifies, in conjunction with instructions, the correct response. Sv is visual stimulus; Sa auditory. Numbers indicate alternatives.

2. Response (R). An observable response within the limits set by instructions. Subscripts are used to indicate right (Rc), wrong (Rw) and specify alternative (R_1). Rs_1 is a response to obtain S_1. Ra is speech.

3. Prompt (Src). A stimulus supporting correct response.

4. Reward (G). A tangible reward delivered to a subject.

5. Feedback (FB). An indication of correctness of response independent of reward.

Figure 11.1

Machine:	S			
	Src		FB-G	S'
Subject:		Rc		
Time:	1--------	----------	----------	1
	o			x

Figure 11.1 shows the diagram of a single trial in which the subject is immediately successful. In order, the stimulus (S) is presented in conjunction with a prompt (Src). The subject

gives the correct response (Rc) receives feedback (FB) and reward (G). The machine begins the next trial (S'), the duration of the first trial being x seconds.

Of the components shown in Fig. 11.1, only the stimulus, correct response and feedback seem necessary in automated teaching. While it is conceivable that a program could exist that does not require the occurrence of the correct response, previous work in both human learning and educational psychology offers good evidence for rejecting this as an effective training situation.

Time Interval

When trials are massed, two known decremental factors may operate. The first is the familiar performance factor, called by Hull inhibitory potential. A second, more rarely investigated, is the possible increase in proactive and retroactive interference that may result from massing. There is some question as to the existence of the second of these effects (Hovland, 1951). Improvement in performance is clearly related to the number of reinforced trials, and if no decremental factors were to operate, the rate of learning per unit time (learning/time) would increase as the degree of massing increases. However, with the operation of decremental factors, learning/time is probably maximized at some degree of massing intermediate to pure spaced, at which learning per trial (not learning/time) is maximized and pure massed.

One experimental approach would be to determine, using experimenter-controlled intervals between trials the degree of massing that maximizes learning/time for a particular set of materials. A second set of problems would include determining whether the best experimenter-controlled interval yields higher learning/time than subject-controlled trial interval. If subject-control were to prove superior, its effect could be broken down into an effect based on the better apportionment of time to allow for differences in trial difficulty and an effect, possibly motivational, associated with the subject's control of the situation.

It would seem most likely that subject-control of pacing would not maximize learning/time for small amounts of material, particularly if differences in trial difficulty were minimized. The most efficient pace under these circumstance would probably be a constant, relatively hurried one, and variations from it would reduce efficiency. Over large amounts of materials, however, subject-control may be a requisite for the subjects' continued tolerance of the task. If, in fact, this is the case, work on spacing of trials could be used to build in delays between response and subsequent trial that would prevent extreme degrees of massing.

The possibility, mentioned earlier, that massing may increase proactive and retroactive interference raises a further consideration, namely, that the interval between the response and the succeeding trial may be a variable, independent of length of trial. That is to say, the retention of the correct response may be interfered with if the response is followed cloasely by a new stimulus and any responses, such as orienting responses or implicit verbalizations, which are elicited by it.

Use of Reward

Rewards can take any number of forms, and within each, a continuum of values. A thorough study of even a few of these add an enormous number of treatments to a research program without insuring the inclusion of the particular method of controlling behavior that may be the sole recourse of a teaching machine user. It would, nevertheless, be important to study rewards if it were the case that some of their dimensions interacted with the other variables being considered. There is however, no evidence of interaction from previous work with these variables in human learning. For these reasons, the wisest course would be to avoid an extensive investigation of possible rewards, but rather, to confine the immediate research to several specific problems. As more widespread use is made of automated teaching techniques, greater knowledge of different rewards and of the possible existence of interaction effects will naturally accrue.

Assuming, then, the availability of tangible rewards, the main problem is one of setting up the contingencies between response and reward. There is little question that the subject's immediately making a correct response, as shown in Fig. 11.1 should be followed by reward. If the subject makes one or a series of wrong responses a number of outcomes, shown in Fig. 11.2 could follow at the discretion

Figure 11.2

Right response

Machine:	S		FB-G	S^1
Subject:		Rc		

Wrong response

I	Machine:	S			FB-G	S'
	Subject:		Rw	Rw	Rc	
II	Machine:	S	S	S	FB-G	S'
	Subject:		Rw	Rw	Rc	
III	Machine:	S			FB	S'
	Subject:		Rw	Rw	Rc	

of the experimenter. Of these, I resembles familiar correction techniques used in discrimination learning. One difficulty with this procedure can be seen by comparing the consequences of immediate success with success following wrong responses; the only clear difference being the intervention of wrong responses between S and FB-G. Since the presence of wrong responses may on many occasions produce no sense of failure, much increased effort or delay of reward, the consequences are practically the same for right and wrong responses. If responding is, in fact, reinforcing, as appears the case for many other behaviors such as exploration, "rocking," etc.; making the wrong response may actually be preferred. Hively (1959) obtained results that can be interpreted in this manner.

In the last set of contingencies, III, the consequences of immediate success and success following wrong responses are clearly different. In II, constantly returning to the original stimulus may motivate the subject by indicating lack of progress. At the same time, II should furnish higher rates of reinforcement than III.

An issue that immediately intrigues anyone who considers teaching machines is whether knowledge of results, alone, will support behavior over long periods of time. It would be reasonable to test this question only when other aspects of the program are thoroughly developed since a poor program may prove somewhat punishing to subjects.

Response

Criterion responses. Normally, the criterion responses used to test the training of an "educated" subject are writing and speaking. While a human operator easily recognizes and responds to both writing and speaking, machines do not. There are, for example, no phoneme recognizers despite the amounts of effort expended to this end and great practical importance of such a device. The problem of producing a machine that recognizes writing is quite similar. In general, there has been little success in building analogues to the human perceiver. The paper will return to this fact in considering possible research problems.

Response dimensions. For the purposes of training, four important characteristics of a response are:

1. Range of possible responses. When high, there is generally little likelihood of the occurrence of a correct response without prior training. In a composed response in operant conditioning, this dimension can be reduced by considering smaller periods of time. In multiple choice, this range is limited to the correct response and foils. Prompts, and particularly instructions, are also intended to limit response range.

2. Response fractionation. The extent to which the response is divided into small time segments. High degrees of fractionation minimize delay or reward and limit response range.

3. Distinctiveness. For this paper's purpose, distinctiveness can be theoretically defined as the extent to which responses share few or no common elements. High distinctiveness of an individual response insures that components of the response are not conditioned to a variety of new stimuli and, therefore, should reduce interference and insure high retention.

4. Work. Work is considered here as an effortfullness dimension. High levels increase performance decrements and are usually associated with increases in length of trial. Extremely high levels are, of course, unpleasant.

These dimensions will be used to compare composed and multiple choice responses and in the discussion of research problems.

Composed (constructed) response. A composed response is one initiated by the subject. It has a peculiar advantage in that it is usually the same as the criterion and, therein, eliminates problem as to the degree of transfer from the trained to the criterion response. Rather curiously, composed responses take far more advantageous positions on most of the four listed dimensions in operant conditioning than in automated teaching. Specifically, elaborate animal training usually involves high levels of fractionation, restricting both the range of possible responses and the amount of work. Automated teaching techniques have usually worked with large, high work responses, the range being restricted by the use of prompts. The Ferster and Sapon (1958) study seems to illustrate how a program involving large, high work responses can effectively train subjects to leave the training situation. Composed responses are nearly always highly distinctive in both situations.

Multiple choice. A multiple choice response is taken here as any response of choosing an experimenter (machine)-presented alternative. Under this definition falls responses to the various types of "slider" machines. The range of possible responses and the degree of response fractionation can be completely controlled. Work, but unfortunately, distinctiveness are usually both very low.

Research problems. One question that immediately arises is whether to use composed or multiple-choice responses. There is some evidence that composed responses result in better retention, as measured by reproduction, even with time held constant (Fry, 1959). The choice of one or the other mode of response is a question involving only training efficiency when you have highly cooperative subjects. If, however, reward is likely to play an important role in maintaining behavior, another problem arises. As already pointed out, composed responses cannot be automatically scored, and therefore, can only control the delivery of reward through a system, like the one in Fig. 11.3 which uses the subject to score.

FIGURE 11.3

Machine: S S_1 FB-G S'

S_2

S_3

Subject: R_1 (composed response) R (matched R_1 and S_1)

There is the immediate dilemma of whether to avoid such unwieldly arrangements and to explore, using simple multiple choice systems, the wide range of other variables, or alternatively, to attempt to gain a better understanding of the apparent advantages of composed responses with different types of materials. At present, the second appears the best strategy because there is good reason to believe that findings, particularly with regard to interference effects, obtained with multiple choice responses may not generalize to the more distinctive composed responses. In terms of testing the effectiveness of multiple choice responses, there is a question in reading as to what method of training yields the greatest transfer to the criterion response of making a sound upon the presentation of a visual stimulus. The criterion response and three alternative multiple choice situations are shown in Fig. 11.4.

Another issue applying to all multiple choice situations, is the effect of number of alternatives. A rather rough extrapolation from Blackwell's work in psychophysics (1953) would suggest the use of no more than four alternatives. Beyond questions as to the number of alternatives, their manipulation constitutes the easiest method of controlling difficulty. Constantly difficult or simple foils could be compared with a program in which foils are used to insure a progressive refinement of discrimination, going from no alternative to far out alternatives to highly similar alternatives. A further question is whether to retain a single set of foils at a particular level of difficulty or to change all foils every time an item appears.

Prompts

Broadly considered, there are two general classes of prompts: continuously varied and discrete. The first class includes methods

FIGURE 11.4

Machine: S_1v FB-G $S2v$ Reading

Subject: R_1a (criterion)

- -

I Machine: S_1v S_1a FB-G $S_2'v$ Responds

Subject: Rs_1 R_1 to get

alternative

auditory

stimuli

for choice

II Machine: S_1a---S_1a---S_1a FB-G $S_2'a$

Subject: R_1

III Machine: S_1v (picture) FB-G S'

Subject: R_1v (choose word)

IV Machine: S_1v (printed word) FB-G S'

Subject: R_1v (picture)

V Machine: S_1v (printed word) FB-G S'

Subject: R_1a (choose sound on right or left)

of indicating the correct response in which the degree of indication lies on a continuous scale, such as lighting the answer or bringing it into focus. Discrete prompts are unscaled clues such as logical clues and the letters left in a word whose spelling must be completed by the subject.

Israel's recent study (1960) seems to eliminate continuously varied prompts as potentially useful devices by finding no growth in response strength prior to unaided recall. Kaess and Zeaman

(1960) have shown, using college student $\underline{S}$s and complex materials, that the superiority of prompting depends, only upon indicating the correct responses. Continuously varied prompts, as used by Israel, would seem unlikely to be more effective than the simpler methods of Kaess and Zeaman in hastening unaided recall.

Programming

General

The main problems in programming are, on one hand, to reduce interference effects, and on the other, to make the best use of earlier learning in training new responses. The main manipulatable variables are (Bond refers to a single association of observable stimulus and response, such as saying "cat" to printed word 'cat'.):

1. number of bonds trained as a group (this is a restatement of a part-whole; group can range from one to any number of bonds).
2. overlearning of bonds within group;
3. similarity of stimuli and responses within group;
4. and, the utilization of previously learned sequences in setting trial order, e.g., sentences in learning language.

The enormous variety of ways of combining material and the educated guess that all four variables might prove important would argue, at least, in the area of verbal learning, for continuing the work of Underwood (1957) and others toward developing a theory of interference effects.

Branching

Branching is the response of the program to the subject's pattern of success. In general, it can be used either to recover lost materials or to vary size of step according to the subject's ability. In each case, there is a detection problem, i.e., sensing the loss of training and assessing ability. In general, an effective program for simple material would either not require branching, or alternatively, would use it only in going from session to session.

Educational Criteria

Recent work in human learning has shown that problems of transfer from training situation to criterion responses may be no less a problem in automated teaching than they are in armed forces' training (Gagne and Bolles, 1959). The difficulty is not that of replicating performance conditions in the training situation, but rather, a basic theoretical one.

As made clear in the Underwood article (1957), retention cannot be equated, in every instance, with learning. In fact, the point of the cited article is that later lists learned to the same criterion are learned and forgotten faster than earlier lists. At least one implication is that comparisons of training techniques should be based, not only on some rate of learning measure, but also on retention tests.

References

Blackwell, H. R. Psychophysical thresholds: experimental studies of methods of measurement. Univ. Mich. Engng. Res. Inst. Bull., 1953, No. 36, 227 p.

Ferster, C. B., & Sapon, S. M. An application of recent developments in psychology to the teaching of German. Harv. Educ. Rev., 1958, 28, 58-69.

Fry, E. B. Teaching machines: an investigation of constructed versus multiple-choice methods of response. Automated Teaching Bulletin, December, 1959, 11-12.

Gagne, R. M., & Bolles, R. C. A review of factors in learning efficiency. In Automatic teaching; the state of the art. (Edited by E. H. Galanter) New York: John Wiley & Sons, 1959.

Hively, W. Implications for the classroom of B. F. Skinner's "Analyses of Behavior." Harv. Educ. Rev., 1959, 29, 37-42.

Hovland, C. I. Factors influencing the rate of forgetting of communicated material. Science, 1951, 114, 481-482.

Israel, M. L. Variably blurred prompting: I. Methodology and application to the analyses of paired associate learning. J. Psychol., 1960, 50, 43-52.

Kaess, W., & Zeaman, D. Positive and negative knowledge of results on a Pressey-type punchboard. J. exp. Psychol., 1960, 60, 12-17.

Lumsdaine, A. A. Some issues concerning devices and programs for automated learning. In Teaching machines and programmed learning. (Edited by A. A. Lumsdaine and R. Glaser). Washington, D. C., National Education Association, 1960.

Skinner, B. F. Teaching machines. Science, 1958, 128, 969-977.

Stolurow, L. M. Teaching machines and special education. Educ. Psychol. Measmt., 1960, 20, 429-448.

Underwood, B. J. Interference and forgetting. Psychol. Rev., 1957, 64, 49-90.

Zeaman, D. Skinner's theory of teaching machines. In Automatic teaching: the state of the art. (Edited by E. H. Galanter). New York: John Wiley & Sons, 1959.

Chapter 12

Support vs. Non-Support in an Autoinstructional Word Program for Educable Retardates

Leonard S. Blackman[1] and Edward A. Holden, Jr.

Recent enthusiasm over the pedagogical benefits of programmed instruction has been stimulated largely by the fact that this approach to instruction developed as a direct extension of data and knowledge acquired in learning laboratories (Kendler, 1959; Melton, 1959; Skinner, 1958). Educators have been informed that programmed instruction represented a major technological breakthrough in educational psychology. A number of studies demonstrated the greater effectiveness of programmed instruction compared with "regular" instruction in such areas as teaching electronics to Air Force mechanics (Briggs & Besnard, 1956), spelling to elementary school children (Porter, 1959), and physics to high school students (Klaus & Lumsdaine, 1960).

Some investigators reported that programmed instruction, in contrast to conventional methods, tended to reduce the relationship between intelligence and performance on the program (Detambel & Stolurow, 1956; Porter, 1959). Clearly, the implication is that, within limits, programmed instruction represents a technique for facilitating task mastery regardless of the level of intellectual endowment brought to the task.

With security born of a proliferating literature and good public relations, researchers in programmed instruction seem to be less concerned with establishing its value relative to regular instruction and more concerned with comparing the effectiveness of different types of programs. Illustrative of these endeavors are studies which have compared (a) multiple choice and constructed response modes (Fry, 1960), (b) instruction presented by different program vehicles such as programmed textbooks and teaching machines (Eigen & Komoski, 1960), and (c) programs utilizing prompting and confirmation techniques (Cook & Kendler, 1956; Cook & Spitzer, 1960; Kimble & Wulff, 1953).

Since the intent of the present study is to contribute to an understanding of the differential effects of prompting and confirmation techniques in teaching four words to non-reading, educable mentally retarded adolescents, a brief review of the status of the prompting-confirmation controversy appears indicated. Prompting is here defined as the introjection of one or more supporting or eliciting stimuli between the cue-stimulus and required response, designed to maximize the probability of effecting the response appropriate to the cue-stimulus. For any constructed response mode, prompts (supports) have taken, among other imaginative innovations, the form of providing a preview of the correct response or some approximation to it, or of having the correct response complete a rhyming couplet.

---

[1] Now Associate Professor of Special Education, Teachers College, Columbia University.

In the multiple-choice response mode, prompts have included underlining the correct alternative, increasing its clarity or brightness, eliminating foils, and providing pictorial and auditory identification of the correct response. The confirmation technique, on the other hand, is characterized by a completely unsupported response to a cue-stimulus, the correctness of which is established after the response is made.

A theoretical predilection for the use of prompts in the development of programs can be traced to Skinner's emphasis on the gradual shaping of complex responses and to his view that the subject should seldom be wrong during his progress to criterion. Glaser (1961) has outlined the following four guiding principles in program development: reinforcement, progression, prompting, and the fading or vanishing of prompts.

The value of using prompts to develop a program that is finely graded and nonconducive to errors, thereby producing higher levels and more rapid rates of learning, has received wide empirical support. Cook (1958), Cook and Kendler (1956), and Cook and Spitzer (1960) found prompting to be generally superior to a confirmation technique in a series of paired associate learning studies. The final study concluded that the reason for this superiority was that overt practice and the resulting delay between the stimulus and response terms inherent in the confirmation method precluded proper facilitation of learning the response terms and their essential S-R connections. Kimble and Wulff (1953) found a prompted group superior to a "no-guidance" group in learning to read logarithmic scales. Studies of educable mentally handicapped children in community special classes and in a residential institution gave further support to the relatively greater effectiveness of prompting, as opposed to confirmation procedures, particularly under a stringent learning criterion (Stolurow, Hasterok, & Ferrier, 1960; Stolurow, Peters, & Steinberg, 1960).

A study by Koronakas (1960) reported results at variance with those cited above. Comparing five methods of teaching reading skills to mental retardates, he found that a confirmation procedure was the best method of instruction. A prompting procedure, in which a picture was used as a prompt for the word cue-stimulus, was found to be next most effective. Amsel (1960) cast some theoretical reflections on the question of whether the attempt to eliminate errors, characteristic of the prompting technique, is the most effecient way to promote learning under all conditions. He concluded that the elimination of errors is desirable when a complex behavior is being shaped. After the behavior has been shaped to a given level, some partial reinforcement schedule which permits errors is desirable if continued refinement and persistence of the same behavior is a program objective.

The central problem of this investigation was to determine whether a support program (prompting) is more effective than a non-support program (confirmation) in teaching four words to equated groups of educable, non-reading, adolescent retardates. An automated self-instructional device or "teaching machine" with a button-press, multiple-choice response mode was the vehicle of program presentation. Program effectiveness is defined as (a) the number of responses required to complete successfully 16 randomized test frames terminating each of the programs, (b) the number of these four words successfully read from cards immediately after completion of the program, and (c) the number of these four words successfully read from cards approximately 24 hours after training.

Since the weight of previous research and the proclamation of outstanding researchers in this field are heavily on the side of prompting or support as an appropriate guide to programming, the following hypotheses are stated.

1. The group trained under the Support program will make fewer errors, thereby requiring fewer responses than the group trained under the Non-Support program to complete the identical 16 randomized test frames terminating each of the programs.

2. As a result of the higher levels of original learning anticipated under the Support program, the group trained under this regime will be able to read a greater number of the four words, both immediately after training and 24 hours later, than the group trained under the Non-Support program.

3. The relationship between IQ and program performance, as measured by the number of responses required to complete the test frames, will be negative for both groups and higher in the Non-Support than in the Support group.

4. The "shaping" nature of the Support program will result in no significant increase in the number of incorrect responses as the learner progresses from full support, through reduced support, to the test frame categories. Grouping of frames in the Non-Support program analagous to those in the Support program, however, will produce a decreasing pattern of errors as the learner moves from his initially high error levels for unsupported frames to some degree of learning over trials.

A rationale for the response pattern hypothesized for the Support program is that the greater difficulty of the reduced support and test frames will be compensated for by the learner's increased readiness to respond to these as a function of his prior training. From another point of view, it can be argued that the decreasing pattern of errors characteristic of the typical, negatively accelerated learning curve will not emerge, since the full support frames initiating this program permit the learner to begin at the bottom of the curve, and gradual support reduction results in the learner remaining there in spite of increasing frame difficulty.

Method

Subjects

Ss were 13 male and 11 female educable retardates in residence at the Edward R. Johnstone Training and Research Center. All were classified as non-readers on the basis of the Wide Range Achievement Test and had previous experience with a prototype of the auto-instructional device employed in the present study. Division of Ss into two equated groups was made on the basis of IQ and of performance on a previous auto-instructional non-support word program. Group I, trained on the Support program in the present investigation, was characterized by a mean CA of 188.33 months, a mean MA of 95.08 months, and a mean IQ of 53.42. Group II, trained on the Non-Support program containing the same four words, was represented by a mean CA, MA, and IQ of 188.17 months, 91.50 months, and 52.42, respectively. The transfer of one female S who had been tested on the earlier non-support program necessitated unequal assignment of males and females to the two programs, resulting in seven males and five females in Group I and six males and six females in Group II.

Apparatus

An automated self-instructional device, designed and constructed by Biophysical Electronics, Bala Cynwyd, Pa. was employed for presenting the stimulus materials. This device, a 14 3/4 in. high x 21 1/2 in.-wide console, was situated on a table so that its horizontal midline was approximately at S's eye level. A 6 3/4 in. square milk glass screen constituted the area upon which a group of four words and their appropiate supports were displayed from a 35 mm. film strip projector within the console. The four words were presented inside arrow configurations arranged in vertical order on the right half of every projection image, each arrow pointing to one of four buttons also arranged in vertical order 1 3/4 in. from the screen's right margin. These buttons were 1/2 in. in diameter, with 1 1/4 in. between centers.

Above the projection screen and continuous with its upper margin was a 1 1/2 in. high x 3 1/2 in. wide milk glass area within which correct and incorrect button depressions were indicated. Depression of the correct button was immediately followed by a 1 1/2 in. green square projected for 1 1/2 sec. on the left side of this area, its offset then followed by progression of the film strip to the next frame. An incorrect response was followed by a red square of identical size and duration on the right side of this area, the film remaining stationary. When a button was depressed, it was automatically illuminated and temporarily locked into position, preventing subsequent button depressions until the appropriate reinforcement indicator light had appeared and terminated. Audio instructions, presented over earphones from a tape recorder within the console, automatically informed S of which word to select each time the film strip advanced and a new frame appeared on the screen.

Programs

Differential experimental treatment was effected by two film strip programs, one with diminishing visual and auditory supports and the other with no support whatsoever. Both programs were designed to teach the words turtle, banana, violin, and shovel, Thorndike frequency values for which are 13, 13, 11, and 14, respectively.

Group I received the visual and auditory Support program, which consisted of 52 film strip frames presented sequentially during a single experimental session. The right half of each frame contained a randomized vertical arrangement of the words turtle, banana, violin, and shovel, the corresponding button for one of which S was told to depress by specific audio instructions presented each time a new frame appeared on the projection screen. Visual and auditory supports accompanied successive frames according to a pre-planned sequence which effected discrete support reduction as S progressed through the program. The first eight frames were accompanied by full visual and auditory support, to be designated as the "picture-word-read" condition (P-W-R), the order of correct responses being two successive frames each of turtle, banana, violin, and shovel. The following description of the first P-W-R frame will suffice for all subsequent frames in this category. In addition to the four words arranged vertically on the right, the left half of frame 1 contained the picture of a turtle with the word "turtle" beneath it. S was instructed to look at the picture of the turtle, then at the word "turtle" under the picture, and finally at the four words beside the buttons. These four words were read from top to bottom, after which S was instructed to press the button next to "turtle".

After two successive P-W-R repetitions for each of the four words there followed a sequence of four support reduction blocks, each containing seven frames representing four conditions of diminishing visual and auditory support. The correct word for each block followed the same sequence in which it was originally presented during frames one through eight. In the first frame of each block the correct word was given full support (P-W-R). Support for the second and third frames of every block, designated "picture-read" (P-R), was diminished by removing the identifying word from under the picture. Audio instructions were modified accordingly, S now being told to look at the picture and then at the four words as they were read from top to bottom.

Visual and auditory support for the fourth and fifth frames within each block was further reduced by eliminating the picture and its associated audio instructions. In this support category, designated by "read" (R), S was instructed to look at the four words as they were read from top to bottom.

In the last two frames of each block all support was withdrawn. S was presented with the four vertically arranged words, and for block one, instructed to press the button next to "turtle." These two terminal frames in each word block are designated as "non-support" (o_1) within blocks.

After all four words had been presented in their respective support-diminution blocks, a terminal series of 16 non-support (o_2) test frames was presented. This series was composed of four randomly distributed repetitions of each of the four words and functioned as a learning test for these words previously presented under conditions of diminishing support.

Group II received a Non-Support program, which consisted of the same four words in an identically ordered 52 frame sequence. Each frame contained only the randomized vertical arrangement of the four words accompanied by audio instructions to press the button beside the appropriate word. The correct word, and its position within each frame, was identical to the corresponding frame in the Support program.

Procedure

S was seated before the auto-instructional console. A pre-instructional test of S's ability to read the subsequently appearing program words was then administered by presenting him with four 3 x 5 in. cards, upon each of which had been typed one of the four words. The cards were handed to S one at a time in random order, and whenever S stated he did not know a word he was urged to guess. Room lights were extinguished and a rubber cushioned headset fitted to S's ears. Since all Ss had participated in at least one previous experiment employing a similar auto-instructional device, it was not necessary for E to provide any preliminary instructions. E then initiated the program, after which there was no explicit communication between E and S until its termination. E recorded S's performance in terms of number of responses required to press the correct button. According to this procedure, perfect performance for any frame was represented by a number "one" beside the correct word, learning for the entire sequence thus being inversely related to the summated value of the highest number on each frame. When S had completed the program, an immediate post-test, identical to the pre-test, was administered. Before presenting these cards, however, it was emphasized that the word on each card was one of those he had seen on the projection screen. After completion of the experimental session, Ss were rewarded for participating and invited back for a few minutes the following day. Approximately 24 hours after completing the auto-instructional program, Ss returned for a retention test of their ability to read the four words presented the previous day.

Results

Since several of the analyses were based on comparisons involving different numbers of frames, all summary data are reported in terms of mean number of responses per frame. In all analyses, the .05 significance level will be used to evaluate the reliability of differences and relationships.

Table 12.1 summarizes the means, standard deviations, and significance tests relating to the first two hypotheses.

Table 12.1

Means and S.D.'s of Responses per Test Frame, Immediate Post-Test Reading Score, and 24-Hour Retention Test Reading Score (N=12 for Each Mean)

		Support	Non-Support	t[a]
Number of responses per test frame O_2	Mean	1.38	1.70	1.23
	S.D.	0.60	0.70	..
Immediate post-test	Mean	3.08	2.33	1.25
	S.D.	1.50	1.44	..
24-hour retention test	Mean	2.68	2.08	1.04
	S.D.	1.15	1.56	..

[a] A t value of 2.07 is necessary for significance at the .05 level of significance. None of the obtained t values is significant.

Hypothesis 1, which predicted that Group I (Support) would take fewer responses than Group II (Non-Support) to complete the 16 randomized test frames was not verified by the data, although a trend in the predicted direction can be noted.

Hypothesis 2, which stated that Group I would be able to read a significantly greater number of the four words trained, both on an immediate post-test and after 24 hours than Group II, was not supported. The trend, however, was again in the predicted direction. The proportion of words retained after 24 hours, as compared to immediate post-test performance, was 87 per cent for Group I and 89 per cent for Group II.

Hypothesis 3 predicted a higher negative relationship between IQ and number of responses required on the test frames in Group II (Non-Support) than in Group I (Support). Although the trend is in the predicted direction, as represented by Pearson rs of $-.49$ and $-.38$ for Group II and Group I, respectively, neither value nor the difference between them, obtained by Fisher's Logarithmic z'Transformation (.32), was significant.

Hypothesis 4 anticipated no significant increase in errors or number of responses as the learner progressed through the various full and reduced support categories and test frames of the Support program. It also predicted a significant decrease in number of responses for comparable groupings, in terms of frame position, in the Non-Support program. Both predictions were confirmed, with Friedman's two-way analysis of variance yielding Chi-square values of 2.97 ($P > .05$) for differences between the Support program categories and 11.87 ($P < .05$) for differences between analogous Non-Support program categories.

There was almost no increase in responses for the P-W-R, P-R, and R categories of the Support program. There was a slight increase in the o_1 (test frames within blocks) category and a fairly marked increase in the o_2 (randomized terminating test frames) category. The increases in the o_1 and o_2 categories, however, were not of sufficient magnitude to affect the analysis of variance which reported no significant over-all differences between categories. The position-comparable frame categories in the Non-Support program showed a steady decline in mean number of responses until the last 16 test frames where there was a relatively marked increase in responses. As stated above, the over-all differences between these categories were found to be significant.

Discussion

The general finding that a Support program (prompting) for teaching four words does not facilitate significantly better performance than a Non-Support program (confirmation) in equated groups of educable mentally retarded non-readers is in sharp distinction to most studies already done on the efficacy of prompting as a programming technique. It might be argued that although the statistical tests did not yield significant values, differences were, in all analyses, consistently in favor of the Support program group. Conceivably, larger Ns in the two groups may have produced significant findings.

It is equally possible that the Support program was not sufficiently well written to produce the degree of superiority over the Non-Support program necessary to achieve statistical significance. The credence to be attached to this possibility is somewhat obscured by conflicting data. On the one hand, the sample of non-reading retardates exposed to the 20 min. Support program was able to read an average of 3.08 words out of four immediately following training and 2.67 words 24 hours later. By most special education standards, this would be considered a high quality performance. On the other hand, there was a marked increase in errors over the final 16 test frames as compared to the training segment of the program. This leads one to believe that there is a significant lack in the program. Obviously, the three discrete supports and their gradual reduction over the 36 training frames were not sufficient to bring the learner to the point of complete achievement as evidenced by errorless performance on the test frames.

One of the specific difficulties of the Support program is that training proceeds in a series of response sequences; i.e. after the first eight frames, turtle is the correct response seven consecutive times, banana is the correct response for the next seven consecutive frames and so on for violin and shovel. By subjective impression, this type of program appears to produce a set for sequential responding over a series of frames. Needless to say, this set is inappropriate for the 16 randomized test frames and may play an important part in the relative disruption of performance over these frames. Future studies will focus on this and other problems related to program quality.

One further comment concerns the relative time lengths of the four-word Support and Non-Support programs. Since the Support program, as designed for this study, contains a good deal of audio description of the frames, it is, of necessity, about twice as long (20 min.) as the Non-Support program (10 min.). If, therefore, the Support program proves to be only slightly better, it may not be worth the greater time investment entailed. This would appear to be a general problem that program writers and evaluators must face--i.e., the amount of learning considered acceptable per unit length of program time.

Summary

Two equated groups of educable, non-reading retarded adolescents were compared in their performance on a Support (prompting) and a Non-Support (confirmation) program designed to teach four words. The dependent variables were number of responses required to complete 16 test frames, the number of these four words successfully read from cards immediately after training, and the number of words successfully read 24 hours after training. An automated self-instructional device or "teaching machine" with a button press, multiple-choice response was the vehicle of program presentation. Although learning occurred and

differences between the two groups were consistently in the direction of better performance under the Support program, none of these differences was reliable. An hypothesized inverse relationship between IQ and number of responses required to complete the program, with this inverse relationship greater for the Non-Support than the Support-program, emerged but did not reach significance. As anticipated, there was no significant difference between mean number of responses on the various full support, reduced support, and test frame categories of the Support program. Significant differences were found, however, between analagous categories of the Non-Support program.

References

Amsel, A. Error responses and reinforcement schedules in self-instructional devices. In A. A. Lumsdaine & R. Glaser, (Ed.) Teaching machines and programmed learning. Washington, D.C.: National Education Association, 1960.

Briggs, L. J., & Besnard, G. G. Experimental procedures for increasing reinforced practice in training Air Force mechanics for an electronic system. In G. Finch & F. Cameron, (Ed.) Symposium on Air Force Human Engineering, Personnel and Training Research Washington, D.C.: National Academy of Sciences-National Research Council, Pub. No. 455, 1956 (Library of Congress Card Catalog No. 56-60063).

Cook, J. O. Supplementary report: processes underlying a single paired-associate item. J. exp. Psychol., 1958, 56, 455.

Cook, J. O., & Kendler, T. S. A theorectical model to explain some paired-associate learning data. In G. Finch & F. Cameron (Ed.) Symposium on Air Force Human Engineering, Personnel and Training Research. Washington, D.C.: National Academy of Sciences - National Research Council, Pub. No. 455, 1956 (Library of Congress Card Catalog No. 56-60063).

Cook, J. O., & Spitzer, M. E. Supplementary report: prompting versus confirmation in paired associate learning. J. exp. Psychol., 1960, 59, 275-276.

Detambel, M. H., & Stolurow, L. M. Stimulus sequence and concept learning. J. exp. Psychol., 1956, 51, 34-40.

Eigen, L. D., & Komoski, P. K. Research Summary No. 1 of the Collegiate Automatic Teaching Project. Report to the Fund for the Advancement of Education, June, 1960.

Fry, E. B. A study of teaching machine response modes. In A. A. Lumsdaine & R. Glaser (Ed.) Teaching machines and programmed learning. Washington, D.C.: National Education Association, 1960.

Glaser, R. Principles and problems in the preparation of programmed learning sequences. In Papers of the Regional Research Conference on Newer Educational Media, Pennsylvania State University, 1961.

Kendler, H. H. Teaching and psychological theory. In E. H. Galanter (Ed.) *Automated teaching: The state of the art.* New York: John Wiley, 1959.

Kimble, G. A., & Wulff, J. J. The effects of "response guidance" on the value of audience participation in training film instruction. Washington, D. C.: Air Force Human Factors Operations Research Laboratories (Report No. 34), 1953.

Klaus, D. J., & Lumsdaine, A. A. An experimental field test of the value of self-tutoring materials in high school physics. An interim report of progress and preliminary finding. Pittsburgh, Pa.: American Institute for Research, April, 1960.

Koronakos, C. A comparison of five methods of teaching basic reading skills to the mentally retarded. Unpublished study presented at the Allerton Park, Illinois Conference, 1960.

Melton, A. W. The science of learning and the technology of educational methods. *Harv. Educ. Rev.*, 1959, *29*, 96-106.

Porter, D. Some effects of year-long teaching machine instruction. In E. H. Galanter (Ed.) *Automated teaching: The state of the art.* New York: John Wiley, 1959.

Skinner, B. F. Teaching machines. *Science*, 1958, *128*, 969-977.

Stolurow, L. M., Hasterok, S. G., & Ferrier, A. Automation in Education. Unpublished study presented at Allerton Park, Illinois Conference, 1960.

Stolurow, L. M., Peters, S., & Steinberg, M. Prompting, confirmation, over-learning, and retention. Invitational paper read at annual meeting of Illinois Council of Exceptional Children, Chicago, 1960.

Chapter 13

Achievement Measurement and Academic Grade Placement in Educable Mental Retardates

George H. Saxton, Leonard S. Blackman
and
Maurice I. Tretakoff[1]

In planning reading and arithmetic instructional programs for mentally retarded students, the accurate assessment of their grade level status and prognosis is a challenging and time consuming task for educators, administrators, and psychologists. It must be recognized that many of these grade placements are relatively inadequate, even when made under ideal conditions, e.g., with individual diagnostic tests and careful school record analyses. However, at an operational level, circumstances frequently dictate grouping students with less than ideally complete information. Quick placement may be accomplished by employing some standardized test, and ". . . selection of a test to use depends on the function to be served. The test user should ask what inferences do I want to make; what information do I need to make those inferences" (Wesman, 1956)?

Two tests useful in grade placement are the California Achievement Test (CAT) and the Wide Range Achievement Test (WRA). It should be noted that the more comprehensive CAT has greater potential than the WRA for extensive diagnostic analysis. If the test user intends to use this type of information, the CAT would appear to be indicated. If, however, the purpose of testing is only for overall grade placement, and if the CAT and WRA predict this placement for mental retardates equally well, the WRA would seem desirable in that considerably less time is involved in administration and scoring. This obtains even though the reading sub-test of the WRA requires individual administration.

The purpose of this study was: (a) to compare the CAT and the WRA in terms of differences obtained in grade level scores for the mentally retarded population; (b) to determine their relationship with individual tests of intelligence; and (c) to obtain intercor-relations between these two tests. An estimate of the validity of these tests for measuring spelling grade level was also obtained.

Method

Ss were 109 institutionalized male and female educable retardates. The mean IQ of this group was 65.8 with a σ of 9.02. The mean C.A. was

---

[1] Now Director, Hope School, Springfield, Illinois.

15.7 years, with a σ of 1.49. The IQ tests were individually administered to all Ss by the Johnstone Center Psychology Department staff. The Wechsler Intelligence Scale for Children was used with Ss under 16 years, and the Wechsler Adult Intelligence Scale with Ss 16 years and older. The WRA and CAT were administered to all Ss by professional staff. Arithmetic, reading, and spelling grade placement scores were obtained with both tests. Teachers' grade placement ratings for spelling, after having taught students for one semester, were available for 37 Ss. These ratings were related to the spelling grade placement scores from the achievement tests. Arithmetic and reading grade placement ratings by teachers were not considered as the teachers had been given their students' achievement test grade level scores at the beginning of the semester, and this could have affected their ratings. No such information had been given regarding spelling grade level.

Table 13.1

Correlations between CAT, WRA, and IQ Scores,

and Means and t Tests between

CAT and WRA Grade Level Scores (N=109)

		I Correlation w/IQ	II Correlation between Sub-scales	III Mean Score for Sub-scales	IV t Tests
Arithmetic	CAT	.51*	.83*	3.66	3.40*
	WRA	.50*		3.49	
Reading	CAT	.31*	.86*	3.43	5.33**
	WRA	.30*		3.11	
Spelling	CAT	.30*	.81*	3.66	12.28**
	WRA	.28*		2.80	

* P<.01.
**P<.001.

Results

In column 1 of Table 13.1 the product-moment coefficients of correlation between IQ, and CAT and WRA sub-scales are shown. The two achievement tests had highly similar relationships with estimates of ability, arithmetic achievement correlating highest of the sub-scales with IQ. The correlations between the achievement tests for the different sub-scales were also quite high and significant as shown in column 2.

The mean grade level arithmetic, reading, and spelling scores for the two achievement tests are shown in column 3 and t tests for significance of differences between the means are shown in column 4. The CAT yielded significantly higher grade level estimates than the WRA in all three subscales.

Using the achievement test spelling grade estimate as a predictor and teachers' grade level ratings in spelling as a criterion measure, a validity coefficient of .82 was obtained for the WRA and .73 for the CAT. These rs were converted into Fisher's z coefficients and were found not to differ significantly.

Discussion

The results indicate high correlations between the tests in assessing arithmetic, reading, and spelling achievement. The mean grade level ratings, however, were significantly different. The implications of this are difficult to analyze in terms of selecting a test for grade placement. The significant statistical differences may not necessarily imply practical differences for the classroom teacher. For example, in no case was there a difference of as much as one grade level between the tests. The teacher would presumably find it quite challenging attempting to prepare differentially for the "significant" ($P < .01$) difference of .17 of a grade for arithmetic achievement. Furthermore, assuming the differences obtained by these tests were of practical value, selection of the more accurate test would be difficult due to the apparent lack of meaningful validation studies in this area with mentally retarded Ss. The attempt at estimating validity for the spelling sub-scales in the present study resulted in a higher, but not significantly different, relationship between the WRA and teachers' ratings, than between the CAT and teachers' ratings. The unusually high validity coefficients are probably a function of the similarity of material and operations in the predictor and criterion variables.

The highly similar relationships between the achievement tests and IQ scores indicate that achievement-ability discrepancies could be inferred equally well by either the WRA or the CAT. It is of importance here that individual IQ measures were used in the present study. Coleman and Cureton (1954) and Kelley (1927) have demonstrated that group IQ measures and group achievement tests overlap so greatly that inferences regarding ability-achievement discrepancies from such measures are not warranted. Yet many studies have continued to treat these group measures as if they were assessing different phenomena. The present study yielded higher correlations between arithmetic achievement and IQ than between reading achievement and IQ, whereas Holwinski (1959) found the reverse to obtain. It should be noted, however, that the latter study employed borderline and normal Ss, and a group rather than individual intelligence test.

Summary and Conclusions

The California Achievement Test (CAT) and Wide Range Achievement (WRA) were administered to 109 educable mentally retarded Ss. The purpose of the study was: (a) to compare CAT and WRA grade placements in arithmetic, reading, and spelling; (b) to relate these tests to individual tests of intelligence; and (c) to estimate their respective validity in measuring spelling grade level. Both tests yield highly similar rs with intelligence. Highly significant rs of the order of .80 were obtained between the two tests. The CAT grade level estimates were significantly higher than the WRA in all cases. These differences, however, are in most cases not large enough to have practical implications for the classroom teacher. A validity coefficient for the spelling sub-scale, derived from correlating test scores with teachers' ratings was slightly, but not significantly, higher for the WRA than the CAT. It may be concluded that the similarity between the CAT and the WRA, both in terms of their relationship with intelligence test scores and with each other, favors the WRA for grade placement for reasons of time economy.

References

Coleman, W. and Cureton, E. E. Intelligence and achievement: the "jangle fallacy" again. *Educ. psychol. measmnt.*, 1954, *14*, 347-351.

Holwinski, I. The relationship between intelligence (80-110 IQ) and achievement in basic educational skills. *Train. Sch. Bull.*, 1961, *58*, 14-22.

Kelley, T. L. Interpretation of educational measurements. Yonkers, N.Y.: World Book Co., 1927.

Wesman, A. G. Aptitude, intelligence, and achievement. *Test Serv. Bull.* 1956, No. 51.

Chapter 14

Effects of Different Learning Conditions on Short and Long Term Retention[1]

George H. Saxton

The lack of parameters of retention presents a serious deficiency in the literature which becomes magnified at a time when data on learning processes are being used, frequently with considerable extrapolation, in the development of automated teaching programs. Furthermore, education is certainly as concerned with retention as it is with learning, and Underwood and Richardson (1957) have shown that retention is not a simple function of learning. With degree of learning held constant, efficient learning conditions do not necessarily result in better retention than less efficient conditions. Knowledge to enable some prediction of retention performance at different time intervals, as a consequence of the training condition employed, seems indicated for learning theory and education.

The purpose of the present study was to investigate the effects, and possible interactions of different learning conditions on short and long term retention intervals. Three learning conditions; knowledge of results, type of response, and degree of learning, were varied. Knowledge of results (feedback) and, more specifically, immediate feedback (Ammons, 1956; Wolfe, 1951) has been empirically demonstrated as being desirable for efficient learning. The importance of the constructed or more active response mode, as compared with the recognition, or less active response, has been stressed by Krumboltz and Weisman (1962). Increasing the degree of learning and/or overlearning has also been shown to improve retention (Krueger, 1929; Gilbert, 1957).

Method

"More efficient" and "less efficient" training conditions were varied by employing a 2x2x2 factorial design, using the following groups: immediate and delayed feedback, constructed and recognition response, and 10 and 15 training trials. A pilot study (N=30), using what theoretically should have been the least efficient training condition (delayed feedback - recognition response) had shown that all but one S reached criterion of one perfect performance after 10 trials. Therefore, it was decided to run half the Ss to 10 trials, and half to 15 trials, approximating criterion and 50% overlearning respectively for most Ss.

---

[1] The author expresses his gratitude to Drs. Belver Griffith and Phillip Siegmann for their help in the experimental design and to Drs. Herman Spitz and Stanley Wechkin for critically studying the manuscript.

Subjects and Procedure: Ss were 389 male and female undergraduate students enrolled in an introductory course in psychology at Trenton State College. Five paired-associates consisting of three consonant units of controlled association value were employed: SLH - XCL, CMG - SHQ, DBM - PSC, GMB - TBX, JBR - ZNH. All data were collected through group testing, each S having a booklet 8.5 x 3.5 in., with instruction, study, and response pages indicated. E read with Ss the following instructions which appeared on the front page of each booklet.

> In this experiment, your task will be to memorize nonsense syllables. The syllables are to be learned in pairs. The stimulus syllable will always be presented and you must memorize the response syllable of the pair, i.e.,
>
> the letters you will see → ABC - XYZ ← the letters
> you must memorize,
> as paired with ABC
>
> All of the materials are arranged in book form. The experimenter will tell you when to turn each page. Turn the page immediately when told to do so. Turn one page at a time. Do not turn back to previous pages.
>
> You will find instructions in parentheses at the top of the pages. Follow these carefully. Always make a response when the instructions direct. Guess if you are not sure.

Ss were then told to "turn first page," and thereafter E said, "Turn" at ten sec. intervals until all Ss had completed all training trials. The first five pages for all conditions were identical, presenting initial exposure of the five paired-associates. Four different training conditions for four different groups were then used in the booklets. The presentation of materials and instructions were as follows. (1) Immediate feedback - recognition response -- the stimulus member appeared on the left; all five response members appeared on the right in a double-spaced column; instructions in parentheses at the top read, "(encircle correct response -- guess if not sure!.)." The following page presented the stimulus member with the correct response member, instructions in parentheses at the top reading, "(study)." (2) Immediate feedback - constructed response -- the stimulus member appeared on the left; all five response members appeared on the right in a double-spaced column with a dotted line between stimulus and response members, instructions in parentheses at the top read, "(print correct response on dotted line -- guess if not sure!.)." The following page presented the immediate feedback for the response, format being identical to the "study" page described above. It should be noted here that in the constructed or more active response mode, it did not seem desirable to invoke a recall response, introducing another response variable, thus the constructed response consisted of writing out the recognized response. (3) Delayed feedback - recognition response and (4) Delayed feedback - constructed response condition used identical format for presentation of materials. However, the five feedback pages were only presented after S had completed the five response pages. Four randomized orders of feedback pages and presentation of response members on response pages were used to control for serial effects.

Seven proctors (faculty and researchers) served while the learning data were being collected, and Ss not following instructions were noted and their booklets discarded. One week (short term retention) after the learning data were collected, half of the Ss in each group were tested for retention, using the recognition method. The procedure for the retention test was as follows: E read with the Ss.

> "Last week you participated in a learning experiment. Below on the left, the stimulus syllables are reproduced, and on the right are the response syllables that should be paired with the correct stimulus syllables. On the dotted line by each stimulus syllable print the number of the appropriate response syllable."

Stimulus and response syllables were presented in columns, the response members being numbered 1 to 5.

Eleven weeks (long term retention) after the learning session the remaining half of the Ss in each group received a retention test. The procedure was identical to that used with the short term retention group, with the exception of the first phrase of the directions, which read here, "Early in the semester ... etc." All Ss took the long term retention test; however, in the analysis only the scores of those Ss who had not taken the short term retention test were used. Ss were identified by sex, initials of their mother's maiden name, and month and day of their birth, instead of their names, in order to assure them of anonymity and minimize any need for cheating.

Results

Learning data, represented by mean scores for the eight experimental groups for each of the first ten trials were analyzed and curves were plotted. After the second trial, the four groups with delayed feedback and the four groups with immediate feedback clustered together with no overlapping. Learning curves were then plotted for the delayed and immediate feedback groups, and are shown in Fig. 14. 1.

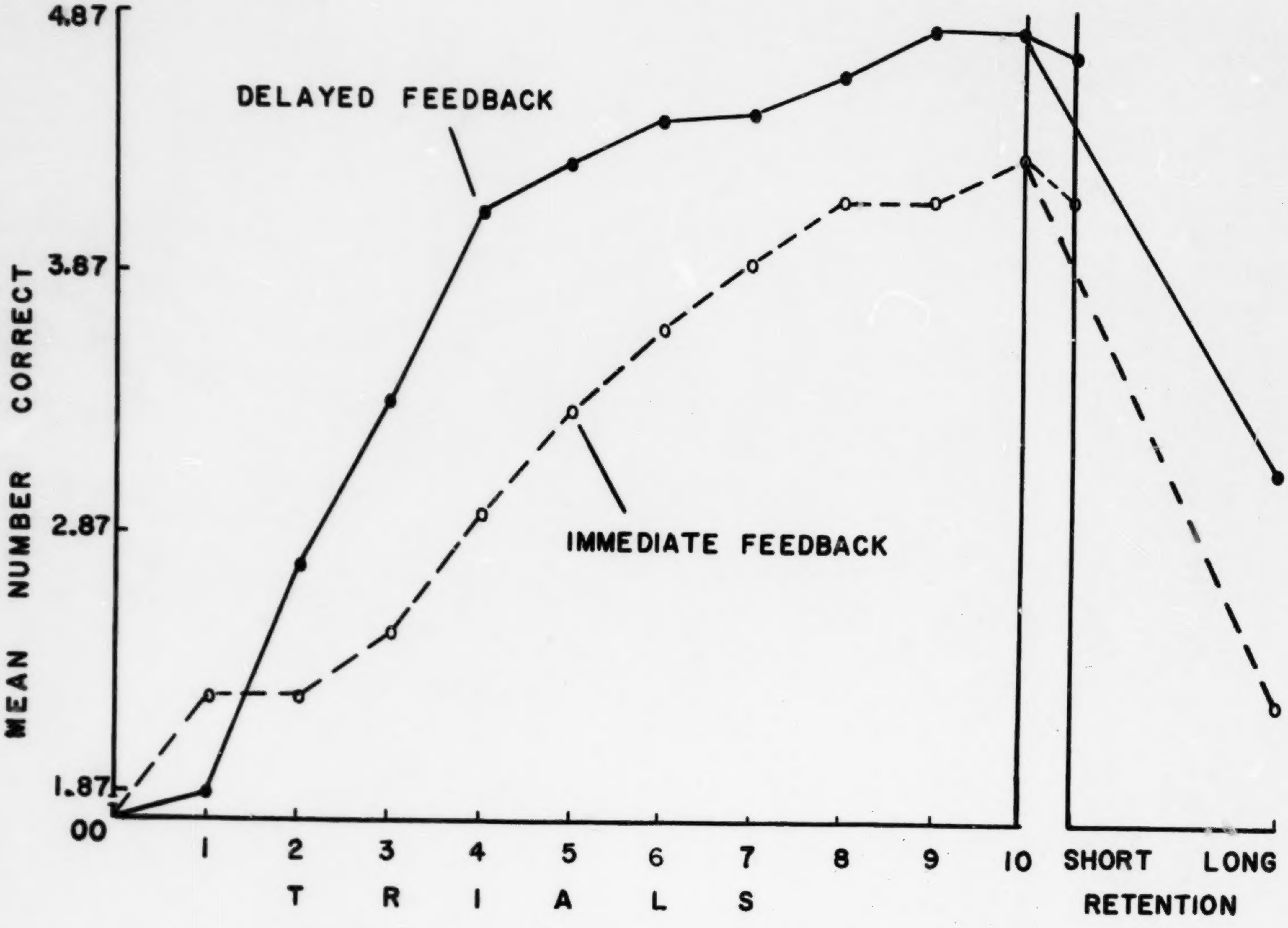


Fig. 14. 1. Learning curves and short and long term retention intervals for immediate and delayed feedback conditions.

It should be noted that the delayed, not the immediate feedback training condition yielded the superior learning. The curves also indicate that before assessing retention the learning differences should be considered. Coefficients of correlation were computed between the mean number of correct responses during the last three learning trials and retention scores for immediate and delayed feedback groups at both retention intervals. Product-moment coefficients were .45 and .31 for immediate feedback, short and long term, respectively, and .28 and .26 for delayed feedback, short and long term. Product-moment coefficients of .43 and .34 were obtained for learning and total short term and long term retention groups, respectively. Coefficients of this magnitude rule out the need for a covariance analysis in studying retention.

The results of the analysis of variance (2 x 2 x 2 - Feedback X Response Mode X Trials) are summarized in Table 14.1 for both retention intervals. Since the data for the short term retention group do not satisfy the assumption of homogeneity of variance, the .01 significance level was required. Twelve Ss were randomly eliminated from the short term, and 24 from the long term groups to make the cells proportional for the analysis of variance test. Several Ss had previously been eliminated because they did not follow instructions and/or did not attend the second testing session. The resulting N's were 158 for the short term and 164 for the long term data.

In the short term retention analysis, no significant differences were obtained for response mode or number of trials, and no interactions approached significance. The F for feedback was highly significant ($P < .001$), with the delayed feedback training condition yielding better retention than immediate feedback. Over the long term retention interval the delayed feedback group retained 65% and the immediate feedback group 52%, of what had been learned by the tenth trial.

The long term retention analysis showed the delayed feedback superiority persisting ($P < .001$). Here, the F for number of trials now reaches significance, with 15 trials demonstrating better retention than 10 trials. Again, there were no significant differential effects as a result of response mode, nor did this variable interact significantly with the other variable.

Discussion

The results indicate that none of the different learning conditions interacted at either retention interval, and more efficient learning was related to better retention. However, the superiority of the delayed feedback training group over the immediate feedback training group in both learning and retention is incongruous with what most theorists would presumably predict, on the basis of past empirical findings (Ammons, 1956; Wolfle, 1951). It is not likely that this is a statistical artifact, since the design of the study involved replication by the two retention intervals. Furthermore, Battig and Brackett (1961) obtained highly

Table 14.1

Analyses of Variance for Short and Long Term Retention Data for 8 Different Experimental Groups

	Short Term (N= 158)			Long Term (N= 164)		
Source	df	MS	F	df	MS	F
Feedback	1	14.88	12.10**	1	32.84	11.86**
Response	1	3.97	3.23	1	.61	—
No. Trials	1	3.44	2.80	1	14.64	5.29*
F x R	1	1.19	—	1	.37	—
F x T	1	.18	—	1	1.18	—
R x T	1	.56	—	1	5.72	2.06
F x R x T	1	.21	—	1	1.18	—
Within	150	1.23		156	2.77	

* $P \leq .05$

** $P \leq .001$

similar learning curves using paired-associates (shape-number). Their two training conditions closely approximated what was termed delayed and immediate feedback in the present study, and they also found that delayed feedback yielded better learning.

Two hypotheses are suggested in regard to the delayed feedback performance. (1) A grouping, or "whole" method of learning, which improved performance, was facilitated in the delayed feedback condition. Referring back to the specific conditions, the delay group saw, $S_1 - R_1$, $S_2 - R_2 \ldots S_5 - R_5$ in the feedback trials; whereas, the immediate feedback group only saw the S-R pairs grouped as such on the initial presentation of the pairs, which the delayed group also received. The immediate group then had to make a response between each presentation of the feedback frames, which possibly interfered to some extent with grouping the material as a whole. Some of the hypothesized attributes of whole learning might then be considered, such as increased meaning through potentially greater numbers of associations (between S-R pairs, as well as between S and R members of a particular pair). The retention superiority for the delayed condition may also be related to whole learning phenomena. Hsiao (1940) found the whole method to yield better retention than part method learning, both immediately and one week later, and concluded that the advantage of whole learning may be increased over longer retention intervals. Battig and Brackett (1961) invoke a somewhat similar explanation, but stress the separate presentations of the entire S - terms, "which might be expected to enhance the identification of the set of material to be learned, as well as to facilitate the differentiation of the items from each other... "(p. 63). They suggest as an alternative explanation that differences in the intertrial interval may have been a factor; however, this was eliminated in the design of the present study. (2) Another hypothesis is that the delayed feedback training condition was more similar to the method of testing retention than the immediate feedback condition. The delay was possibly analoguous to a brief retention interval, motivating delayed feedback groups more than immediate feedback groups to develop techniques conducive to better retention (and learning), e.g., a greater number and/or more efficacious mnemonic devices. Also, the grouping of S-R pairs in the delayed feedback condition (discussed in hypothesis 1.) may have been advantageously related to the grouping of items on the retention tests.

The possibility that the length of delay given to the delayed feedback group was not sufficiently long to have hindered learning is contradicted by Holland (1959), and Saltzman (1951), the latter finding only a 6 sec. delay significantly hindered learning. However, much more information about the specific parameters of delay and immediate feedback is needed before this variable can be ruled out. Two studies have demonstrated better retention for delayed than for immediate feedback training, supporting the hypothesis that correct response-produced cues were used more effectively in the delayed feedback condition (Brackbill and Kappy, in press; Brackbill, Bravos, and Starr, in press). However, in the present study, differential use of response-produced cues was unlikely, as the delayed feedback group was making different responses every 10 seconds, allowing little opportunity for covert response practice.

The lack of significant differences between constructed and recognition response modes suggests, that, at least with simple paired-associates, a more covert response is as effective for both learning and retention and is quicker than more overt responses (Goldbeck, 1960). It should be noted that these findings have little implication for Skinner's stress on "composing" a response. The present study varied a more active with a less active multiple choice response; whereas Skinner (1958) emphasized the need for a recalled response, and questions the desirability of recognition response modes which encourage the possibility of making wrong responses.

Another factor might be the criterion of learning and retention. Fry (1959) found a constructed response mode to yield better learning than recognition, when achievement was measured by recall; but, no differences when learning was measured with multiple choice criteria.

References

Ammons, R. B. Effects of knowledge of performance: A survey and tentative theoretical formulation. *J. gen. Psychol.*, 1956, *54*, 279-99.

Battig, W. F., & Brackett, H. R. Comparison of anticipation and recall methods in paired associated learning. *Psych. Rep.*, 1961, *9*, 59-65.

Brackhill, Yvonne, Bravos, A., & Starr, R. H. Delay-Improved retention of a difficult task. In press.

Fry, E. B. A study of teaching machine modes .... Teaching machines and programmed learning. Washington, D. C. Nat. Educ. Assn., 1960.

Gilbert, T. F. Overlearning and retention of meaningful prose. *J. gen. Psychol.*, 1957, 56, 281-89.

Goldbeck, R. A. The effect of response mode and learning material difficulty on automated instruction. Tech. Rep. 1, Office of Naval Res. Contr. NONR-3077 (00), American Institute for Research, Pittsburgh, Penna.

Hsiao, H. H. An experimental comparison of the whole and the part method of learning. Stud. Educ. Psychol., Nat. cent, Univ., 1940, No. 2, 63. In *Psychol. Abstracts*, 1941, 15, No. 2542.

Krueger, W. C. F. The effect of overlearning on retention. *J. exp. Psychol.*, 1929, *12,* 71-78.

Krumboltz, J. D., & Weisman, R. G. The effect of overt versus covert responding to programmed instruction on immediate and delayed retention. *J. educ. Psychol.*, 1962, *53*, 89-92.

Saltzman, I. J. Delay of reward and human verbal learning. *J. exp. Psychol.*, 1951, *41*, 437-439.

Skinner, B. F. Teaching Machines, In A. A. Lumsdaine & R. Glaser (Eds.) Teaching Machines and Programmed Learning. Washington, D. C., Nat. Ed. Assn., 1958.

Underwood, B. J., & Richardson, J. Studies of Distributed Practice: XVII. Interlist interference and the retention of paired consonant syllables. *J. exp. Psychol.*, *54*, 1957, 274-279.

Wolfle, D. Training. In S. S. Stevens (Ed.) Handbook of Experimental Psychol., New York: Wiley, 1951.

Chapter 15

Word Learning in an Automated Teaching Situation as a Function of Display Condition

Stanley Wechkin[1]

In teaching Ss with little or no reading achievement to "read" a word, i.e., emit the correct oral equivalent of an orthographic symbol, in an automated teaching situation, one is confronted with two givens. First, there is a strong predilection towards multiple-choice devices, since it is extremely difficult to construct a machine which recognizes correct composed responses, or for the S to do so himself. Secondly, the device must present both the written word and its auditory equivalent. A problem arises as to the best display arrangement of the material in terms of giving the fastest learning rate and/or the greatest retention. Specifically, should the printed word to be learned be presented visually and the correct equivalent and its foils auditorily, or should the equivalent be presented auditorily and the correct orthographic symbols and its foils visually? This question touches upon two somewhat separate problems: the efficiency of learning in the auditory and visual modality, and the relative facilitation of learning as a function of stimulus and response meaningfulness.

The available evidence on learning as a function of the sensory modality involved (as reviewed by Henmon, 1912; Koch, 1930; McGeoch & Irion, 1952, pp. 480-484) is confined to studies in which the stimulus and response terms were of a given modality or combination of modalities. Stimulus and response terms in these studies were both auditory or visual, or the stimulus terms were both auditory and visual and response was oral and/or orthographic. This literature indicates that there is much disagreement as to the most efficient modality. More germane evidence is in the area of the relative meaningfulness and familiarity of stimulus and response terms. In terms of the present problem the auditory term, if it is a common word, would be meaningful; and the visual term, the printed word, would be initially, relatively meaningless. The studies of Cieutat, Stockwell, and Noble (1958), and Hunt (1959) show that high response meaningfulness is more important in accelerating learning rate than high stimulus meaningfulness and would indicate that the condition under which auditory response alternatives are used should give faster learning. In addition, this problem can be viewed in terms of the transfer paradigm, with the auditory response alternatives condition involving positive transfer and, hence, faster learning because the S is connecting an old response, a common spoken word, to a new stimulus. In the visual alternatives situation there would be negative transfer and slower learning, with the S connecting a new orthographic response to the old stimulus of the spoken word.

---

[1] Now Research Associate, The Medical School, Northwestern University.

The present study was undertaken to shed empirical light on this subject. Trigrams were used to insure a situation where a surrogate for the printed word be unknown. In order to make the two situations comparable in regard to temporal aspects of response terms, it was decided to forego the advantage that might accrue to a visual response alternatives condition in an actual learning situation as a result of concurrent presentation of alternatives, and present them consecutively instead.

Method

Materials

Two equivalent lists were used for each of the two response conditions: A_I and A_{II} for the auditory alternative response condition (Lists I and II), and V_I and V_{II} for the visual alternative response condition (Lists I and II). The stimulus items for the A lists and the response items for the V lists were printed, low association, three-letter consonant units used by Witmer (1935). The response terms for the A lists and stimulus terms for the V lists were spoken, high frequency, four-letter monosyllabic nouns. There was low similarity among stimulus items and among response terms for any given list, as well as between stimulus and response pairs. There was a total of six paired associates in each list. Each stimulus item was followed by two response alternatives and this constituted a set. The incorrect alternative for the stimulus item in a set was the correct one for the stimulus item in another set, i.e., alternatives were "inside." Six sets of stimulus items and response alternatives composed a trial, and the trials were arranged in cycles of four. The order of the six sets within a trial was randomized. The alternatives were arranged so that the incorrect response item was different for each stimulus item in the four-trial cycle. The stimulus-response alternative combinations and their order in the two conditions were the same for any list number. For example, in List A_I the first set consisted of the visual stimulus XFQ followed by the spoken response alternatives *wind* and *cake*, with *cake* correct. The second set of this list was FHJ followed by *hair* and *aunt*, with *hair* correct, and so forth, until all six pairs had been presented. List V_I was the analog of this. The first set here consisted of the auditory stimulus *cake* followed by the visual response alternatives CQH and XFQ, with XFQ correct. The second set was *hair* followed by FHJ and ZXJ with FHJ correct. Similarly, Lists A_{II} and V_{II} were analogs of each other. The reason for this method of list construction was to prevent uncontrolled variation in difficulty of experimental conditions as a result of differences in ease of association of particular stimulus-response combinations. To prevent position guessing habits from yielding similar variation, the randomized position of the correct response alternative (first or second) was the same for corresponding sets in all lists.

Apparatus

The consonant units were presented visually on slides projected on a wall and the common words were recorded on magnetic tape and presented auditorily. The presentation device was a LaBelle Maestro II combination tape recorder and slide projector (manufactured by LaBelle Corporation, Oconomowoc, Wisconsin). This device allowed for a signal placed on the magnetic tape to trip the slides, and all presentations within a set were performed automatically.

Subjects

Thirty-two residents of the State Home for Girls in Trenton, New Jersey, were used. The Ss were all between the ages of 14 and 17 years, and had a minimum of fourth grade reading skills and a minimum IQ of 90.

Procedure

The auditory response alternative lists were presented in the following manner. When the apparatus was activated the visual stimulus consonant unit was presented for 2 seconds. One second after its removal the first auditory response alternative was presented, consuming .4 second. After a 2.6-seconds delay, the second auditory response alternative was presented. Following this, the experimenter stopped the machine, waited for the S's response, gave feedback, recorded the response, and activated the machine for the next set. In the visual response alternatives condition, the auditory stimulus word was presented for .4 second, followed by a 1-second delay before the presentation of the first visual response alternative for 2 seconds. This was followed, 1 second after its removal, by the second alternative for a 2-second exposure. After its removal the experimenter stopped the machine and proceeded as in the auditory condition. Thus, in both conditions the time between onset of stimulus and termination of the exposure of the second response alternative was 6.5 seconds with a constant 1-second interval between the conclusion of the presentation of the stimulus item and the onset of the first response alternative. Because of the desire to hold these two time intervals constant, and the differential temporal nature of auditory and visual exposure modes, the exposure times of stimulus and response items and the times between response alternatives were different for the experimental conditions.

Each S was given two lists to learn, one on each of 2 consecutive days. The study was initially designed to have each S serve as his own control, and the first 16 Ss were randomly assigned to Groups A_I-V_{II} (the first two symbols-A_I-refer to the first day's response condition and list number, respectively; the second two symbols--V_{II}--to the second day's response condition and list number), A_{II}-V_I, V_I-A_{II}, and V_{II}--A_I. When these Ss had been run, it became apparent that differential transfer effects were confounding Day 2 scores. For this reason, the second group of 16 Ss was randomly assigned to Groups A_I-A_{II}, A_{II}-A_I, V_I-V_{II}, and V_{II}-V_I. Thus there were four Ss in each of the eight groups that could be composed by varying condition, list number, and order.

Prior to the presentation of the first list, each S was told what a consonant unit was, and that she was to learn to connect this with a common word. She was told that she would have no idea at the beginning which was the correct alternative and to guess, but to try and remember the correct one. The S was asked to say "First" if she thought the first response alternative was the correct one, and "Second" if she thought it was the second one. The experimenter said "Right" or "Wrong." The Ss were instructed to learn as quickly as possible and to guess when not sure. Criterion was errorless performance on 2 successive trials, and the cycles of 4 trials (or 24 sets) were repeated until criterion or the maximum of 36 trials. Prior to learning the second list on Day 2, retention was tested by presenting the S with the printed individual consonant units in random order and asking for the common word associated with it. Guessing was encouraged. Retention of the list learned on Day 2 was tested on Day 3. A total of 23-24 hours separated each session, and the same experimenter ran all the Ss on all sessions.

Results

The means of the learning and retention scores by condition and day are shown in Table 15.1. Because there appeared to be overall

Table 15.1

Mean Trials to Criterion and Amount Retained as a Function of Presentation Mode

Mode	Day 1				Day 2			
Days 1 & 2	Trials	SD	Retention	SD	Trials	SD	Retention	SD
A A	31.50	6.84	1.38	.69	24.13	10.52	1.38	1.41
A V	27.50	6.93	2.63	1.49	17.88	7.59	3.67	1.30
V A	12.50	2.92	3.88	1.27	13.13	8.64	3.25	2.05
V V	11.88	2.76	4.80	1.12	10.50	4.64	3.13	2.03

Note: N per entry=8.

heterogeneity of variance, parametric analysis was performed only on those data where heterogeneity could not be accepted at the .05 level by the Bartlett test. Since list number was not an important variable (Fs for list number on each day as well as those for its interaction with condition on each day were<1.00), it is not considered. The retention scores appear to reflect rate of learning and whether or not criterion was reached, and are not treated separately, since six of the eight Spearman rho's/between trials-to-criterion and number of correct retention responses, calculated by taking each group and day separately, were negative. The differences attributed to display mode (condition) are highly significant on Day 1 (Mann-Whitney U=254.5, $p<.001$), with visual mode clearly superior. Of the 16 Ss in each Day 1 group, 8 of the auditory Ss failed to reach criterion by Trial 36, while the slowest visual S reached it by Trial 16.

The summary of analysis of variance of Day 2 scores is shown in Table 15.2. These data are put in the form of the transfer paradigm (cf. Noble, 1961). The effect of display mode here is not by itself statistically significant; rather, it was affected by the first day's condition and/or performance. The two groups which had the visual condition on Day 1 and, hence, fewer trials-to-criterion on that day did better in the transfer (Day 2) phase than those that had the auditory condition first. The significance of the interaction in Table 15.2 is attributable to the poor scores of the AA group (CR of difference at .01 level=10.89). The means of Day 1 and Day 2 scores irrespective of

Table 15.2

Summary of Analysis of Variance of Day 2 Scores

Source	df	MS	F
Training (Day 1 condition constant)	1	675.28	10.85*
Transfer (Day 2 condition constant)	1	157.53	2.53
Interaction	1	476.04	7.65**
Error (w)	28	62.64	
Total	31		

$*<.02$.
$**<.01$.

groups--20.84 and 16.41, respectively--were significantly different at the .02 level (F=7.01, df=1/30), indicating an overall facilitation as a result of the first learning task. The effect of similarity of conditions across days, or its interaction with days, was not statistically significant (both Fs <1.00, df=1/30). However, the correlation between Day 1 and Day 2 learning scores for the Ss was positive for those groups having the same condition across days: rho = +.49 and +.25 for Groups AA and VV, respectively; and negative for groups with different conditions: —.11 and —.41 for Groups AV and VA, respectively.

Discussion and Conclusions

Two findings warrant attempts at explanation: the overwhelming superiority of the visual response condition on the Day 1, and rather complex interaction effects reflected in Day 2 scores. In respect to Day 2 scores, it is possible that the initial formulations of stimulus and response were inadequate. Under both conditions the "stimulus" word was absent at the onset of the response alternatives and the S therefore has to retain the stimulus term while making a judgment. In the visual response condition the trace that had to be retained was a simple, common word; in the auditory condition it was an unpronounceable, low association trigram. It may be supposed that the trigram trace was less deeply imprinted and faded more quickly than that of the common word, and that, hence, the S in the visual response condition, in making the judgment of the correct alternative, was responding in the presence of a stronger stimulus than the S in the auditory response condition. In other words, under both conditions two responses had to be made, a retention response, and a judgmental, or associating, response; and the first of these responses was harder to make and stood a lesser likelihood of being successful under the auditory condition. This is admittedly a post hoc explanation, but one which would be necessary to prevent an interpretation of the results which would run counter to the previously cited evidence on response meaningfulness and transfer. It is testable in that one would predict that the auditory response condition, with its greater response meaningfulness, would be the superior one in a situation where the differential stimulus deterioration did not obtain (e.g., where there was presentation of the stimulus simultaneously with the response alternatives).

The transfer effects were not originally an item of primary interest, but rather the result of the self-control design, and here again, though perhaps more justifiably, a post hoc explanation is attempted. There appears to be nothing about the two learning conditions themselves which would give differential transfer, other than their innate difficulty. Overall positive transfer (learning-to-learn) would be expected, and this was found. Hovland (1951, p. 666) summarizes evidence to the effect that negative transfer is maximized under conditions of incomplete learning of the initial task, responses in this situation being poorly differentiated and therefore interfering. Combining these facts, it may be stated that the effect of the Day 1 Condition A on Day 2 learning can be both facilitating and interfering. V on Day 1 can only be facilitative, however, the V condition being initially so easy as to preclude improvements as a function of antecedent conditions. This would explain why Group VV shows no improvement on Day 2, while Group VA does. The increase in trials-to-criterion on Day 2 for Group Av would be attributable to the interfering effect of A on Day 1, the facilitative effect having no room to operate here. The decrease of Day 2 scores on Group AA can be explained if it is assumed that the facilitative effect of A on Day 1 is greater than its interfering effect.

References

Cieutat, V. J., Stockwell, F. E., & Noble, C. E. The interaction of ability and amount of practice with stimulus and response meaningfulness (m, m') in paired associate learning. J. exp. Psychol., 1958, 56, 193-202.

Henmon, V. A. C. The relation between mode of presentation and retention. Psychol. Rev., 1912, 19, 79-96.

Hovland, C. I. Human learning and retention. In S. S. Stevens (ed.) Handbook of Experimental Psychology. New York: Wiley, 1951. Pp. 613-689.

Hunt, R. G. Meaningfulness and articulation of stimulus and response in paired-associate learning and stimulus recall. J. exp. Psychol., 1959, 57, 262-267.

Koch, H. L. Some factors affecting the relative efficiency of certain modes of presenting material for memorizing. Amer. J. Psychol., 1930, 40, 370-388.

McGeoch, J. A., & Irion, A. L. The psychology of human learning. (2nd ed.) New York: Longmans, Green, 1952.

Noble, C. E. Meaningfulness (m) and transfer phenomena in serial verbal learning. J. Psychol., 1961, 52, 201-210.

Witmer, L. R. The association value of three-place consonant syllables. J. genet. Psychol., 1935, 47, 337-359.

Chapter 16

Word Discrimination as a Function of Difficulty Sequences

Stanley Wechkin

It is commonly assumed that an effective method of teaching a difficult discrimination is to have S initially learn easier discriminations. Evidence for this is cited by Lawrence (1952) who also found that rats exposed to gradually decreasing brightness value differences in discrimination training showed fewer errors in the final trials involving minimal brightness differences than Ss that had to make these minimal difference discriminations throughout training. It was decided to test the applicability of this "shaping up" of a discrimination to word learning, using a mentally retarded population.

EXPERIMENT 1

Method

Subjects

Ss were 24 institutionalized male and female retardates ranging in age from 14 to 19 years, having IQs ranging from 37 to 74, and reading skills ranging from nil to first grade. They were divided into two groups equated on the basis of these variables. Group EH had a mean IQ of 55.00 and Group HH had a mean IQ of 54.58.

Materials

The material to be learned consisted of ten polysyllabic words of seven to ten letters taken from a seventh grade reading list. These words presented with three incorrect alternatives (foils) for six consecutive learning and two criterial trials. The position of the correct word was randomized with respect to the foils. The foils for Group HH, which was required to make uniformly difficult discriminations during training, were composed by permuting the four medial letters of the correct term. For example, the foils for REQUIRE included REIQURE, RERUIQE, etc. No identical foils were used in any single trial.

The foils for Group EH, which was exposed to increasingly difficult discriminations, were composed using a common elements, a priori hierarchy - of - cues scheme. It seemed apparent that the length of a word in relation to other words was a relatively important cue, i.e., it was a discrimination dimension that was likely to be used earlier than others, and once learned, a word was less likely to be confused with words of different length than with words differing on other dimensions. Similiarly, it was assumed that the initial letter of a word was a more important cue than the terminal letter; that the terminal letter was a more important cue than the second letter; and the second letter was a more important cue than any one medial letter. The foils were arranged accordingly. In trials 1-2, they differed from the correct word by a minimum of two letters in length, and in the first, second and last letters. The correct word shared no more than one letter in the remaining positions with the foils. In trials 3-4, the foils either began with the same letter as the correct word but differed with it in length by one letter, or, were of the same length but began with a different letter. The second and last letters of the foils were different from those of the correct word and no more than one of the remaining letters were common. In trials 5-6, all foils began with the same letter as the correct word and were of the same length. The second or the terminal letter of the foil, but not both, was identical to that of the correct word. Again, no more than one of the letters in the remaining positions were common. Foils in criterial trials 7-8 were identical to those in the criterial trials for Group HH.

Procedure

The learning materials were presented on a wall by means of a slide projector. Each of the ten words with foils was presented consecutively for the eight trials. Prior to the introduction of a trial sequence, a slide with only the correct word was shown for 30 sec. while E read and defined it. The word was also read at the beginning of each trial and S was told to point to it amidst its foils. A correction procedure was used, and the number of errors (the maximum being three) was noted.

Retention was tested 24 hrs. after training. S was shown each word and asked to say what it was. This constituted the spoken reproduction or recitation task. Following this, a discrimination-recognition task, identical in administration to the two criterial trials for each word in training was given: i.e. S had to pick the correct word from three minimally different foils.

Results

The error curves for the two groups are plotted in Fig. 16.1. As can be seen from this, the tasks were too difficult to allow learning to take place. Differences between trials 1-2 and 7-8 for Group HH yielded $t < 1.00$, $p > .10$. Nevertheless, the operation of increasing difficulty in the EH condition was successful. The trials x treatment interaction in the analysis of variance was highly significant ($F = 18.74$, $p < .001$), indicating differences in curve slope. Group EH began with almost errorless performance and concluded at a level insignificantly higher than Group HH (criterial trials $t < 1.00$, $p > .10$). Thus, despite the fact that Group EH was exposed to the supposedly facilitative effects of progressively difficult discriminations, superior learning was not reflected in the criterial trials. The lack of differences between the two groups, as well as the absence of learning, is reflected in the retention data. The mean words correctly identified on both recognition trials was 1.08 for Group EH and .91 for Group HH ($t < 1.00$, $p > .10$). The mean number of words correctly named in the reproduction task was .92 for Group EH and .45 for Group HH ($t < 1.00$, $p > .10$).

It may be argued that because of the lack of learning involved in the experiment, the facilitative effect of progressive difficulty had no opportunity to evidence itself. A second experiment therefore was conducted in which it was hoped that a reduction in number of words and an increase in the number of trials would allow learning to occur.

EXPERIMENT 2

Method

Subjects

Ss were 24 male and female retarded students with an IQ range of 38 to 79. The Ss in this group were different from the group used in Exp. 1 only in that all were non-readers. No Ss used in Exp. 1 were used in Exp. 2. They were divided into two groups according to the scheme used in Exp. 1. The mean IQ of Group EH was 53.67 and the mean IQ of Group HH was 53.17.

Materials

Five polysyllabic words taken from the ten used in Exp. 1 were used. Foils were composed for twelve training and two criterial trials for each word. Since the *a priori* easy-to-hard discrimination scheme used in Exp. 1 was successful in terms of yielding an increase in the errors with ascending difficulty steps, it was retained and modified to take into account the increased number of trials and steps. The foils for Group EH for trials 1-2 and trials 3-4 were composed according to the method used for these trials in Exp. 1. In trials 5-6 all foils began with the same initial letter and had the same number of letters as the correct word. The second, next to last, and last letters were different, and no more than one common letter other than the first appeared in both the correct word and the foils. In trials 7-8, length, first, and last letter of the foils were identical to those of the correct word. Again, no more than one other common letter appeared in the remaining positions. In trials 9-10 the correct word and the foils had identical length, first, second, and last letters. Once more, only one of the remaining letters were common. In trials 11-12 the foils were identical to the correct word in length, first, second, next to last, and last letters. Of the remaining letters, two were the same as the remaining letters in the correct word. In trials 13-14, the criterial trials, the foils were the same as in the analogous trials for Group HH. This group had foils composed of permutations of the four medial letters throughout training.

Procedure

Ss were exposed to the learning material in a manner identical to that of Exp. 1. Retention testing differed only in that the recognition tests included one set of foils identical to those used in Trial 7 for the Group EH and one set identical to trial 14, which was the same for both groups.

Results

The error curves for the two groups are plotted in Fig. 16.2. The similiarity of these curves to those in Fig.16.1 is striking. Again, the differences in curve slope were highly significant ($F=15.38$, $p<.001$) with Group HH insignificantly superior ($t=1.57$, 2 sided $p>.10$). The conditions were still too difficult to allow learning to take place, differences between trials 1-2 and 13-14 for Group HH yielding $t=1.44$, $p>.10$. Again, the low level of learning tended to obscure any differences in retention that might have emerged as a function of training conditions. The mean words correctly identified on both recognition trials were 1.00 for Group EH and 1.27 for Group HH ($t<1.00$, $p>.10$). The mean number of words correctly reproduced was the same for both groups: .45.

Discussion and Conclusions

The failure to establish learning in both experiments vitiates all but the most tentative statements about the data. Because of the absence of learning, the effectiveness of the different training methods cannot be assessed. Nevertheless, it is interesting to speculate that if trials and steps were increased, extrapolation of the curves in Fig.16.2 would probably indicate learning for both groups, with no significant difference in the criterial trials, or even a difference favoring Group HH. This would be keeping with the finding that retardates are relatively poor at establishing learning sets (House and Zeaman, 1958), for the EH condition is in fact one which should allow learning sets to occur. The practical implications of such a find would be far reaching. A training procedure with emphasis on rote drill rather than one based on expectations of transfer of a discrimination to a more difficult situations might yield faster learning.

Summary

Two experiments were conducted to ascertain differences in discrimination learning rate and amount retained among high-grade

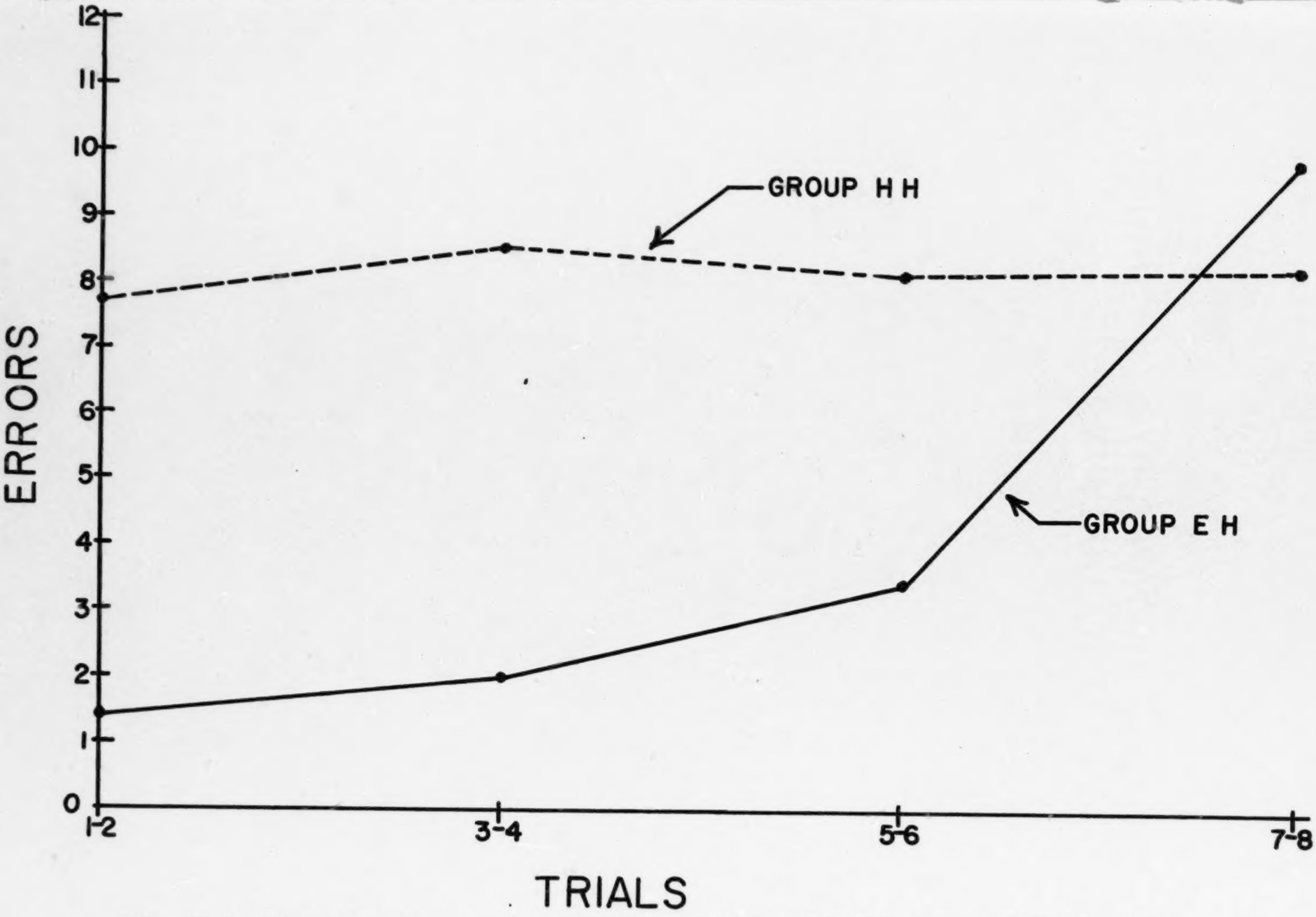


Fig. 16.1. Mean errors per word as a function of differential difficulty sequences (Exp. 1) Chance = 1.5.

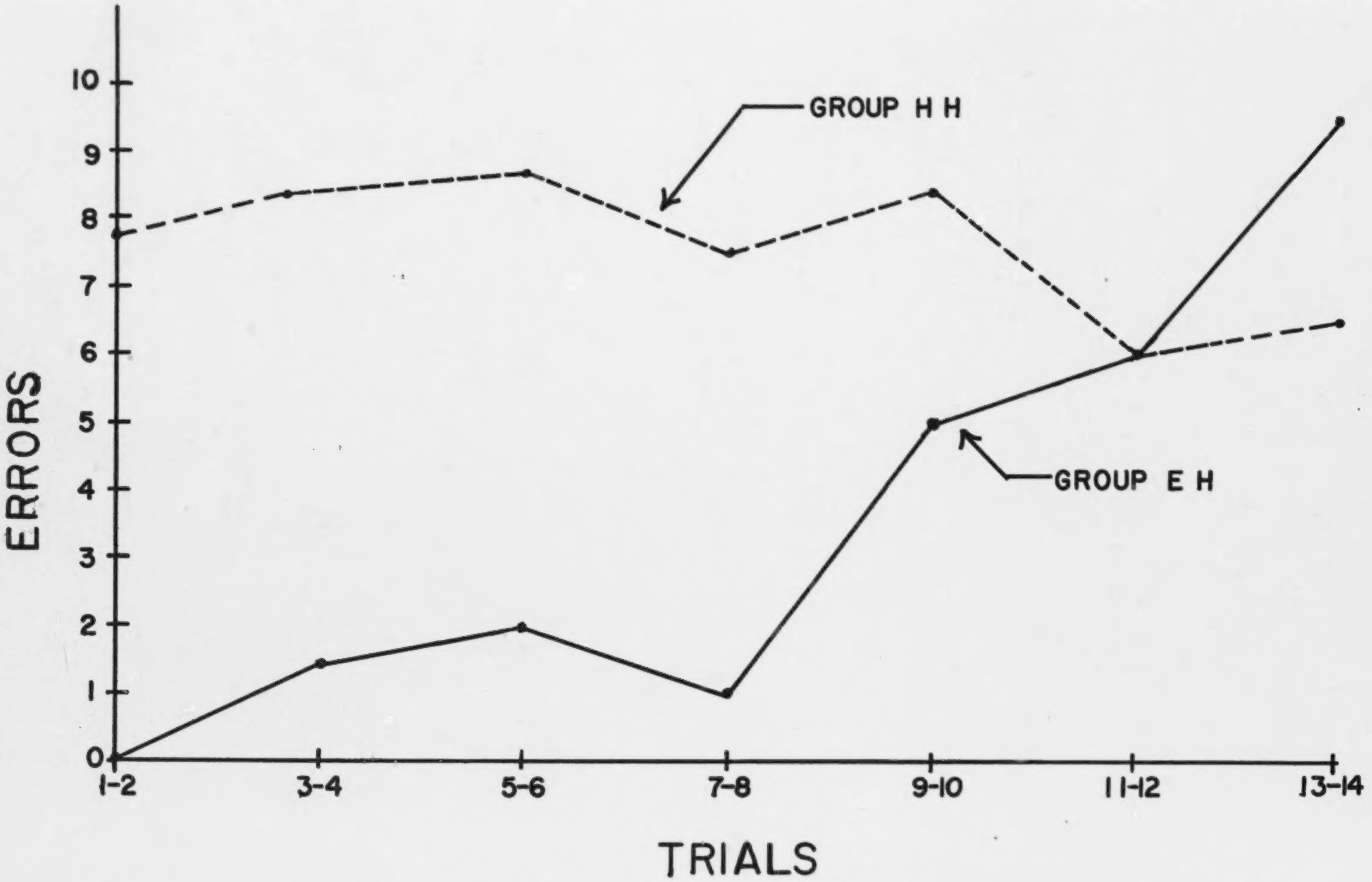


Fig. 16.2. Mean errors per word as a function of differential difficulty sequences (Exp. 2) Chance = 1.5.

retardates as a function of difficulty sequences in word discrimination training. Groups EH were forced to make increasingly difficult four choice discriminations, while Groups HH had to make difficult discriminations throughout. Unfortunately, because the conditions were too difficult to allow learning to take place, no definitive comparisons could be made. Nevertheless, there was an insignificant tendency for Groups HH to be superior on the criterial trials. The implications of this were discussed.

References

House, B. J. and Zeaman, D. A comparison of discrimination learning in normal and mentally defective children. Child Dev., 1958, 29, 411-416.

Lawrence, D. H. The transfer of a discrimination along a continuum. J. comp. physiol. Psychol., 1952, 45, 511-516.

Chapter 17

The Application of an All-or-None Learning Model to Multiple Choice Data on the Acquisition and Retention of Paired Associates*

Ann Heimburg Griffith

Introduction

Recently, the theorizing of Guthrie (1935) that S-R associations are fully learned on a single trial and that forgetting is a result of counterconditioning has received renewed attention and support. The issue was revived by Rock (1957) and Rock and Heimer (1957) who showed, for paired-associates learning, that removing incorrect items from the list after every presentation cycle and replacing them with new items does not retard learning as compared with conventional control groups. If, the authors argued, the strength of S-R associations increases with each presentation of the list, then the incorrect items should have acquired some degree of associative strength and removing them from the list should retard learning of the complete list. If, on the other hand, items are fully learned on a single trial, then removing incorrect items and replacing them with new items should have no effects on the rate of learning.

Other investigators repeated Rock's procedures for paired-associates learning controlling for variables other than repetition, or its absence, and concluded that there were several possible alternative explanations of the Rock effect. Differential item difficulty was found to be a major variable accounting for the performance of the replacement group. Clark, Lansford, and Dallenbach (1960), controlling for idiosyacratic differences in item difficulty, were able to substantiate Rock's findings. Idiosyncratic differences in difficulty, as measured by Clark et al., may not, however, provide a large enough sample of verbal behavior to give reliable estimates of item difficulty. They also found, however, that intra-list interference is greater in the repetition group, where items not learned are retained within the learning series. Battig (1962) and Battig and Birtcher (1962) found that when items in the paired-associates list are carefully calibrated for difficulty the repetition group showed superior performance to the replacement group on a wide variety of stimulus materials. They argued that when differential items difficulty is not controlled the replacement group is, in effect, allowed to select a list containing easier items.

---

*The study, supported by funds made available through this Project, was submitted to Rutgers University as a doctoral thesis.

In a series of experiments, Underwood, Rehula and Keppel (1962) demonstrated that selection occurs for the procedure where incorrect items are dropped from the list being learned and replaced by new items. They found that terminal lists given replacement groups are easier to learn than initial lists. Since, by some mechanism of item selection, e.g., selective attention, lists given replacement groups become increasingly easy to learn, repetition effects for unreplaced lists could be balanced out. The authors concluded, therefore, that Rock's results (that performance of the replacement group was as good as performance in the repetition group) could have been an artifact of item selection and that, therefore, Rock's procedure cannot provide an adequate demonstration of one-trial versus gradual learning. The Battig (1962) and Battig and Birtcher (1962) results that the repetition group is superior for items calibrated for difficulty would appear to support Underwood's conclusions.

Another variable, presentation rate, was found in one study (Lockhead, 1961) but not in another (Clark, Lansford, and Dallenbach, 1960) to reverse Rock's results. The assumption behind these studies was that Rock's presentation rate (5 seconds per item, 3 seconds for interitem interval and 30 seconds between presentation cycles) was slow enough to allow the Ss substantial rehearsal time or time to invent mnemonic devices. If rehearsal is a form of covert repetition, then the replacement group would have benefited from an indeterminate number of repetitions. Clark, Lansford, and Dallenbach (1960) reduced presentation rate to 1 second per item with no interitem interval. They found that the replacement group needed fewer trials to reach criterion than the repetition group. They concluded that mnemonic devices invented during the longer presentation intervals were not responsible for Rock's results. Lockhead (1961) found, however, that reducing presentation rate to .75 seconds per item resulted in a reversal of Rock's results, and concluded that evidence for one-trial learning disappears when rehearsal time is eliminated or greatly reduced.

A third variable found in several studies to reverse Rock's results was method of learning. Brackett (1961) found that when Ss were pretrained and instructed to learn by the "part" method, i.e., to learn only a few items on each trial, the replacement group showed superior performance to the repetition group. This result was reversed, however, for Ss given no pretraining and for Ss pretrained to learn by the "whole" method of trying to learn the entire list on each trial. Another study, however, Battig and Birtcher (1962) failed to obtain systematic effects from pretraining procedures. Postman (1962) forced Ss to spell both the stimulus and response members of each item aloud during training. He found, when, in his words, "Ss were prevented from attending selectively to a few pairs at a time," that performance in the repetition group was superior to performance in the replacement group.

The evidence provided by these studies appears to support the conclusion that the Rock effect was the result of other variables, differential item difficulty appearing the most likely, rather than repetition or its absence. These results, at best, do not rule out one-trial learning. They simply indicate that Rock's procedure may not be adequate to distinguish between one-trial, all-or-none, and incremental theories of learning.

In an entirely different approach, Estes (1960) and Estes, Hopkins, and Crothers (1960), in a series of "minature" experiments in paired-associates learning, presented evidence favorable to an all-or-none theory of learning. For a number of issues in acquisition and retention of paired-associates the authors showed how predictions from an all-or-none theory would differ from predictions from an incremental theory of learning. The first of these issues involves proportion of responses shifting from incorrect to correct after each reinforced[1] trial.

According to the associative strength concept of learning, the strength of S-R connections increases with each reinforced[1] trial. Thus, the function of each trial is to add an increment of associative strength to each S-R connection. In Hull's system (1943) this is expressed as

$$\triangle H = k(M - H)$$

where $\triangle H$ is the change in habit strength (H) on any reinforced trial, M is the maximum value of habit strength, and k is a constant. Similarly, in statistical learning theory, as in Estes' original model (1950) this assumption is expressed as

---

[1] Estes' (1960) definition of reinforcement, which will be used throughout this paper, identifies reinforcement with the operation used by the experimenter to produce learning. In the paired-associates situation, the reinforcing operation is simply the paired presentation of the stimulus and the response members of an item without regard to whether the S correctly anticipated the response member of the item. According to the drive-reduction definition, however, the term is limited to an operation that follows and is contingent upon the occurrence of the reinforced response, i.e., S making a correct response in anticipation of the paired-associates item.

$$\Delta p = 0(1 - p)$$

where Δp represents the change in the proportion of stimulus elements connected to a given response, and 0 is a constant (the proportion of stimulus elements samples on each trial). In the stocastic model of Bush and Mosteller (1955) a linear operator is applied and associative strength is identified with response probability. Thus, according to the associative strength view of learning the effect of the first reinforcement is to increase the probability of making a correct response to each stimulus item from around zero to some intermediate probability greater than zero. Subsequent reinforcements further increase this probability until the probability of a correct response to each item approaches one.

In an all-or-none theory of learning, however, the probability of a correct response to each item can take only two values, zero or one. That is, an item can occupy only two states, fully learned (probability of a correct response equals one) or unlearned (probability of a correct response equals zero). The change in state of an item from un learned to learned takes place in a single reinforced trial and the function of repeated trials is simply to allow the discontinuous formation of additional learned associations. Since according to an all-or-none view of learning trials simply operate to allow some proportion of unlearned items to become learned (shift from incorrect to correct) it is both reasonable and parsimonious to assume that this proportion is roughly constant from trial to trial. The two theories can be distinguished, then, in that an all-or-none theory would predict that roughly a constant proportion of items are learned on each reinforced trial while an incremental theory predicts that an increasing proportion of items will shift from incorrect to correct on each reinforced trial, i.e., that the probability of a correct response to each item increases with each reinforced trial.

Estes' "pattern" model (1959) for all-or-none learning assumes that a constant proportion of items are learned on each reinforced trial. This issue was tested by Estes et al. (1960) in a "miniature" experiment on paired-associates learning. Tests were inserted after each presentation of the paired-associates list, in an $R_1T_1R_2T_2$[2] paradigm. During the test, S is presented the stimulus members of each pair, in a different random order from training, and is asked to supply the response member. This technique, of inserting test trials, provides a measure of the proportion of incorrect items shifting to correct after each reinforced trial.

The results of Estes et al. (1960) supported the "constancy" hypothesis that roughly the same proportion of incorrect items were gotten correct on T_1 after R_1 as shifted from incorrect to correct on T_2 after R_2. In a more impressive demonstration, however, the paradigm was extended to three training-test trial cycles and was applied to eyelid conditioning in an experiment by Gormezano reported by Estes (1960). His data also showed that the proportion of new conditioned responses (represented by proportions of Ss getting conditioned) after 1, 2, and 3 reinforcements was roughly constant (.13, .15, and .14). While the "pattern" model can predict these results, Estes' old statistical model (an incremental model) gives values for conditioned responses following non-conditioned responses of .24[3] for .15 after 2 non-conditioned responses and .34[4] for the obtained value .14 after 3 non-conditioned responses.

The second distinction between an all-or-none and an incremental theory involves responses to "unlearned" items. Estes et al. (1960) have shown how this distinction can be tested for paired-associates learning using a simple $R_1T_1T_2$ learning paradigm. Since, for an all-or-none theory, learning takes place on a single trial, after the first reinforcement, some proportion of the items on the list are fully learned (have probability one of being correct) and the remaining items are unlearned (have probability zero of being correct). For an incremental theory, however, all items on the list should acquire an increment in associative strength from the first reinforcement and, therefore, all items should have some specifiable probability, greater than zero, of being correct.

---

[2] T_n refers to test trial n, where n takes the values 1, 2 . . ., etc., and test trials are consecutively numbered; R_n refers to training trials or reinforcements, where n takes values 1, 2 . . ., etc., and training trials are consecutively numbered.

[3] 0 and p_1 were taken as .13. For the proportion of new CR's after 2 reinforcements, $p = 0\ (1 - p_1) = 13\ (1 - .13) = 13\ (.87) = .113$.

$p_2 = p_1 + p = .13 + .113 = .24.$

[4] For the proportion of new CR's after 3 reinforcements, $p = 0 (1 - p_2) = 13\ (1 - .24) = 13\ (.76) = .0988$

$p_3 = p_2 + p = .24 + .0988 = .34.$

This can be tested, in the $R_1T_1T_2$ paradigm, by determining for individual items, the proportion of incorrect responses on T_1 shifting to correct on T_2. If an all-or-none theory is correct, then incorrect items on T_1 are unlearned items and proportion of incorrect items on T_1 shifting to correct on T_2 should be no greater than chance, i.e., the chance of guessing correctly on unlearned items. If an incremental theory is correct, however, incorrect items on T_1 should possess some degree of associative strength (approximately the same amount as correct items) and, therefore, the probability of incorrect responses of T_1 shifting to correct on T_2 should be greater than chance. It might be noted, however, that this assumes that all items are of equal difficulty. Secondly, according to an incremental theory, if increasing numbers of reinforcements are given prior to testing, associative strength should increase and, therefore, the porportion of incorrect items on T_1 shifting to correct on T_2 should also increase with increasing numbers of reinforcements.

The results of Estes et al. (1960) for a single training trial on an 8-item paired-associates list showed that the proportion of correct responses on T_2 following incorrect responses to the same items on T_1 (0.9) was well below their lowest possible estimate of chance. The authors estimated that, for an 8-item list, the probability of guessing correctly on unlearned items was at least .125 if S guessed from among all 8 response members on the list. (A more reasonable estimate of chance, however, would be higher, since it is unlikely that S guessed from among responses already learned on R_1.) Since .09 is well below what Ss could do according to a conservative estimate of guessing, it would appear that incorrect items had not acquired any degree of associative strength on R_1. Several possible objections, as e.g., that the incorrect responses on T_1 were partially "learned" on T_1 and tended to be repeated or that individual differences or differences in item difficulty could have been factors resulting in a reduction in the proportion of correct responses on T_2 following incorrect responses on T_1, were ruled out by further analyses of the data. Since associative strength is assumed to increase with reinforcements, a more convincing demonstration would be to obtain the result after increasing numbers of reinforcements.

In another area, retention, the theories also yield different predictions. According to an all-or-none theory, S-R connections, once formed, are permanent and can only be broken by having a new response learned to the stimulus, thereby replacing the original response. Thus, retention is assumed to be perfect unless counter-conditioning occurs during the retention interval. Estes' model (1959) for all-or-none learning also assumes that retention is perfect, i.e., "that learned items always yield correct responses on subsequent tests." Except for apparent reductions in retention resulting from guessing correctly and incorrectly on unlearned items, the model predicts that retention of learned items should be perfect over successive unreinforced tests of learning. It might be noted, however, that most studies of retention find that retention losses do occur (Hovland, 1951). These results are not necessarily in disagreement with an all-or-none theory, since it is difficult to rigidly control or specify conditions under which these retention losses occur.

According to most all-or-none theories of learning (Guthrie, 1935, and Estes, 1960, and Estes et al., 1960), since learning takes place on a single trial, retention should not depend on number of previous reinforcements. Predictions from Estes' model for retention, therefore, are based on amount learned during training rather than on actual number of reinforcements. Rock (1957), however, whose results supported an all-or-none theory of acquisition, suggested that additional reinforcements could function to "strengthen" memory once the S-R bond was formed. According to incremental theories, however, since associative strength increases with reinforcements, retention should improve with increasing numbers of reinforcements.

Estes et al. (1960) showed that where successive recall tests followed one or two training trials on an 8-item paired-associates list, some retention loss occurred over successive tests which was not predicted by the model. When four successive tests followed training, however, original losses occurring between T_1 and T_2 tended to remain stable over the remaining tests. The authors tentatively concluded that while retention was somewhat less than perfect there was no progressive weakening of S-R associations over successive test trials. Estes et al. (1960) also found evidence that there may have been "learning" on the test trial itself (learning being defined as an increase in the probability of whatever response, correct or incorrect, occurs to a given stimulus on the test). This may, they felt, in part have accounted for the result that retention losses did not increase over successive unreinforced tests.

The data (Estes et al., 1960) showed further that retention was no better after 2 reinforcements than after one reinforcement. This result may be in disagreement with older, more conventional studies, reviewed by Hovland (1951), which employ great numbers of training trials and which show that retention improves with increasing degrees of learning. Murdock and Babick (1961) found that repetition had no effect on the retention of individual words and they were able to rule out the objection that increased difficulty of repeated words as compared to non-repeated words could have counteracted the benefits of repetition.

A fourth issue which distinguishes between the two theories is whether retention losses occur on an all-or-none basis or whether retention losses represent reductions in response probability to intermediate degrees. According to an all-or-none theory, forgetting should represent complete loss of the item, i.e., the probability of the correct response should become zero and there is no intermediate state. However, according to an incremental theory, the strength of S-R associations can occupy intermediate states, and forgetting need not be complete. To distinguish between these alternatives, Estes et al. (1960) gave three successive unreinforced tests following one or two reinforced trials on the paired-associates list. The relevant data were whether items correct on T_1 but incorrect on T_2 were correct again on T_3. An all-or-none theory which assumes that forgetting is permanent would predict that the probability of a correct response on T_3 following an incorrect response on T_2 and a correct response on T_1 should be no higher than chance, i.e., the probability of guessing correctly on unlearned items. An incremental theory assumes, however, that retention losses can occur to intermediate degrees, and would predict that the probability of a correct response on T_3 following an incorrect response on T_2 and a correct response on T_1 would be greater than chance.

Estes et al. (1960) found that the probability of a correct response on T_3 following an incorrect response on T_2 and a correct response on T_1 was well above their lowest possible estimate of chance. Further, they were able to rule out the possibility that their result could be interpreted as a "sequential" effect, i.e., the possibility that a response given on an earlier test would have a greater than chance probability of recurring on a later test. They concluded, therefore, that forgetting occurs to intermediate degrees.

The overall purpose of the present study was to make a more general test of the predictive powers of Estes' "pattern" model (1959) for the learning and retention of paired-associates. Specifically, the model was used to obtain predictions for acquisition, for responses to "unlearned" items, for retention and for all-or-none forgetting. Estes' work was extended by (1) adding more reinforcement conditions, (2) by employing two forms of a multiple-choice test (2 - and 4-response alternatives) in evaluating retention on the assumption that increasing the number of alternatives increases response interference, and (3) by using different stimulus materials (2-digit numbers paired with 3-letter consonant trigrams).

A secondary purpose was to attempt certain technical improvements on the study of Estes et al. (1960). First, a multiple choice recognition test rather than a recall test of learning was used to avoid difficulties found in the prior study of not being able to provide, in advance, a specific estimate of the probability of guessing correctly or incorrectly on unlearned items. Second, the study was designed with the purpose of providing specific statistical tests of the goodness-of-fit of predictions from the model. For the experimental situation used here, an all-or-none model uses a single empirical parameter in generating predictions for any block of data. There is, of course, no allowance for progressive effects resulting from successive reinforcements. That is, a constant proportion of items should be learned following each reinforcement, and there should be no improvement with retention with increasing numbers of reinforcement.

To distinguish between an all-or-none theory and an incremental one, it is, therefore, only necessary to set up conditions for testing for a progressive effect, over and above predictions from an all-or-none theory, that is associated with increasing reinforcements. For this purpose, the following pattern of data analysis was repeatedly carried out on the data. First, an estimate was made, averaging over a large block of data, of the proportion of unlearned associations conditioned by a reinforcement. Second, this estimate was used to generate predictions from the theoretical model. Third, obtained data were compared (substracted or placed in a proportion, as appropriate) with the predictions. Finally, an analysis of variance was performed on the deviations and its outcome examined for a progressive reinforcement effect that would refute an all-or-none theory.

Method

Subjects

The Ss were 134 female undergraduates enrolled in 5 sections of the introductory psychology course at the women's division of a state university.

Materials for Training

The training materials consisted of 20 number-trigram pairs presented on slides. Twenty 2-digit numbers were chosen, using a table of random numbers with the restrictions that no number could appear twice and that no runs longer than two would be used, e.g., if 27 and 28 were selected, 29 could not be used. The numbers were the stimulus members of the paired-associates list and they were paired, using a table of random numbers, with 20 consonant letter trigrams.

The twenty trigrams were constructed from 20 consonant letters (H, N, R, S, T, C, D, G, L, M, F, K, P, V, W, B, J, Q, X, Z), which were first roughly classified as having high, medium, and low frequency of occurrence in English (Underwood and Schulz, 1960). The trigrams were constructed, using a table of random numbers, with the following restrictions: (1) each letter of a trigram should come from a different category of frequency of occurrence in English, (2) each letter should appear 3 times over the 20 trigrams and could not occupy the same position more than twice, (3) no letter could be repeated in a single trigram. Trigrams which resembled words or well-known initials were eliminated.

Materials for Testing

The tests following training were multiple-choice recognition tests given in booklet form. Two booklet forms were used, a 2-choice booklet and a 4-choice booklet. Test booklets were mimeographed on white paper and measured approximately 3-3/4" in width and 8-1/2" in length. Each test booklet contained 60 test pages, with only one stimulus-response pair (and foil responses) on each page. A cover page contained complete instructions to S. The stimulus member appeared to the left of center of the page and the response and its foils 3 spaces to the right. The response and its foil trigrams were arranged vertically, centered from the stimulus member, with 2 spaces between each trigram. The first 20 pages composed test 1, and second, test 2, and the third, test 3. Each test was, of course, a repetition of the 20 items seen during training along with foil trigrams. Each of the 3 tests in a booklet had a different random order of presentation of the stimulus-response items and each test in a booklet had a different arrangement of foils and correct response trigrams on the page. Only one set of foils was seen on the 3 tests of a single booklet.

To construct foil trigrams for each response, a table of random numbers was used to assign pairs of letters from the pool of 20 consonant letters given above, to each correct response. Restrictions were that (1) each letter in a pair should come from a different category of frequency of occurrence in English, (2) each letter should be used twice over the 20 pairs, (3) the same pair could not occur more than once, (4) a pair could not contain two of the same letter. From these two letters plus the 3 letters in the correct response, 6 foils were drawn by a random procedure for each response. Restrictions on the drawing were that: (1) the number of letters foils had in common with their respective correct response (1 or 2) was roughly equated among responses, (2) no two foils could be alike or similar to another correct response. Foil trigrams that resembled words or well-known initials were eliminated.

By a random procedure, three of the 6 foils for each correct response were assigned as a unit to their respective response composing booklet type A. The remaining 3 foils for each response composed booklet type B. There was one booklet type A for the 4-choice test and three of booklet type A for the 2-choice test (one for each of the three foils appearing in the corresponding 4-choice booklet). The same situation obtained for booklet type B. Different random arrangements of foils and correct responses on a test booklet page were used in each booklet type, and within a booklet type, for each of the three tests. Different orders of presentation were used in each booklet type, and within a booklet type, the order varied among tests. The single restriction was that an item could not follow itself going from test 1 to test 2, from test 2 to test 3.

Design

Three factors, number of reinforcements (varying from 1 - 5), item groups (four randomly-selected groups of paired-associates) and groups of *Ss* were combined in a 5 x 5 latin square. The latin square was repeated at each level of a fourth factor, number of choices in the test booklet. Figure 17.1 shows the design. As seen in Fig. 17.1, each item group received 1, 2, 3, 4, or 5 training trials in a particular combination for each *S* group. That is, a particular group of *Ss* saw a list 60 items long on which 4 of the 20 different items were presented once, 4 twice, 4 three times, etc., but for each group a different combination of training trials and item groups was given. The latin square design insured that all combinations of training trials and item groups was given. The two conditions of the recognition test (2-versus 4-choice) provided a replication of the basic latin square. Thus, groups 1-a and 1-b got the same reinforcement, item group combination during training, but were tested at different levels of number of alternatives in the recognition test. The design is basically a Lindquist (1956) type IV "mixed" design where there are a replications of an a x b latin square. The design was used to counterbalance the effects of group differences and differences among items over treatments (levels of reinforcement), and, in addition, as discussed in the Introduction, the design was used to provide a test for goodness-of-fit of predictions from the model. In calculating obtained scores and in generating predictions from the model, scores were summed across *Ss* receiving a particular reinforcement, item group combination. In the analyses, therefore, there was only one entry per cell and interactions provided the error term for testing main effects. In no case was there *a priori* theoretical reasons for predicting interactions to be significant. For each analysis, interactions were tested for homogeneity of variance.

Since, for each group of *Ss*, certain of the 20 items were presented once, some twice, some three times, etc., to five presentations per pair, items were assigned, using a table of random numbers, to item groups. Since there were 20 items, 4 items were assigned to each of five item groups. A training series consisted of 60 pairs in all; 4 of the 20 presented once, 4 presented twice, 4 presented three times, 4 presented four times, and 4 presented five times. Each group got a different training series in that a particular item group was presented a different number of times for each group.

In order to avoid possible bias due to order of presentation of the items, i.e., possible serial position effects,

	C_2						C_4				
	I_1	I_2	I_3	I_4	I_5		I_1	I_2	I_3	I_4	I_5
G_{1a}	R_1	R_2	R_3	R_4	R_5	G_{1b}	R_1	R_2	R_3	R_4	R_5
G_{2a}	R_2	R_3	R_4	R_5	R_1	G_{2b}	R_2	R_3	R_4	R_5	R_1
G_{3a}	R_3	R_4	R_5	R_1	R_2	G_{3b}	R_3	R_4	R_5	R_1	R_2
G_{4a}	R_4	R_5	R_1	R_2	R_3	G_{4b}	R_4	R_5	R_1	R_2	R_3
G_{5a}	R_5	R_1	R_2	R_3	R_4	G_{5b}	R_5	R_1	R_2	R_3	R_4

Fig. 17.1. Design of the study. C refers to the number of alternatives on the recognition test and subscripts 2 and 4 refer to 2 and 4 alternatives. I refers to item group, G refers to subject group, and R refers to number of successive reinforcements which vary from 1 to 5.

certain restrictions were placed on order of presentation of items during training. The list of 60 paired-associates items given each group was divided, using a table of random numbers, into 4 blocks of 15 items. Each block contained one presentation of items presented once, two presentations of items presented twice, etc., to five presentations of items presented 5 times. The relative position of each of these item groups was varied from block to block for each training series. In this manner, 5 different training series were constructed, one for each group of Ss. The use of a single long list in which different items appear different proportions of the time is a procedure frequently followed in laboratory replications of frequency-of-occurrence effects in language. A sizable number of studies have found regular functions between numbers of reinforcement and AL (Forrest, 1957; King-Ellison and Jenkins, 1954; and others).

Procedure

Each group of Ss was assigned to a particular training series by a random procedure. There were 27 Ss in Group 1, 26 Ss in Group 2, 24 Ss in Group 3, 27 Ss in Group 4, and 20 Ss in Group 5. Groups were further subdivided for testing by randomly distributing both 2-and 4-choice booklets (in equal numbers) over the seats Ss would occupy. Both booklet forms (2-and 4-choice) and booklet types (A and B) were distributed in approximately equal numbers to each group.

Groups were trained using a 500-watt automatic slide projector, and 2 x 2 positive transparencies (black figures on white grounds). There were 300 (15 of each paired-associate) transparencies in all distributed among the 5 training series. Since each group saw a different set of 60 slides, extreme care was taken in manufacturing the slides that no imperfections or systematic differences occurred among the 5 sets of slides.

The experiment was carried out in a large, sound-treated room. The room was arranged so that all seats to be occupied by Ss had a clear view of the projection screen at the front of the room. All materials were organized (focusing of image, distribution of test booklets and pencils) prior to Ss entry into the room.

When a group of Ss entered the room, they were told by E to occupy seats containing booklets, but not to open the the booklet. When everyone was seated, Ss were told to read the instructions on the cover page, then look up. E then read the instructions on the cover page aloud to the group, as follows:

"The experiment is divided into two parts. You will not use the booklet in the first part.

In the first part, slides will be shown. Pay close attention because the slides will be shown briefly. Each slide will contain two digits and a set of letters, like the example below:

99 XYZ

Your task is to learn to associate the letters with the numbers. In the example, you would learn to associate 'XYZ' with '99'.

In the second part, the experimenter will ask you to open the booklet. When you do, you will find one of the numbers that appeared on the slides and several sets of letters. Encircle the set of letters that goes with that number. Guess if you are not sure. The experimenter will tell you when to turn to the next page. Be careful to turn only one page. Please do not turn back."

Ss were further cautioned not to skip pages in the test booklets, to guess if they did not know the answer (i.e., not to fail to respond) and to wait for E to pace their response-time to each item. Any queries by Ss were then answered.

After the instruction period, E went to the back of the room and turned on the projector, projecting a blank frame onto the screen. Ss were given a ready signal, then lights were turned out and the training series was begun. Each paired-associates item was presented for 5 seconds, and there was a 2 second inter-item interval. The entire training session lasted about 7 minutes. After training, normal lighting was restored ans Ss were immediately told to open their booklets. Ten seconds was given for each response. E paced the response-time using a stop watch and simply said: "Turn the page," at the end of each 10-second interval. Ss were proctored and appeared to follow instructions well. One S was eliminated from the tabulations for responding more than once to each item in the booklet and one S was eliminated for failing to respond to several of the pages in the booklet.

Results

Analysis of Acquisition Data

Estes' model was used to predict acquisition scores after 1, 2, 3, 4 and 5 training trials on the paired-associates list. The model assumes that items are fully learned on a single trial, that a constant proportion of items are learned on each trial, and that responses to unlearned items are distributed by chance on a multiple choice test among correct and incorrect alternatives. In the model parameter, c, the probability of an item being learned on a given trial is assumed to be constant and gives the proportion of items learned on each reinforced trial. The general equation is: $P = c + p (1 - c)$ where: P is proportion of items correct; c is the proportion of items learned after each training trial; and p is the probability of guessing correctly on unlearned items.

Because an *a priori* determination of p can be made from the number of alternatives in the multiple choice test, c is the only parameter that needs to be estimated from the data. For example, c can be estimated directly from the proportion of items correct on test 1 (T_1) after one reinforced trial using the expression $P_1 = c_1 + p (1 - c_1)$, where: P_1 is the proportion of items correct after one reinforced trial; c_1 is the proportion of items learned on the first reinforced trial (except for random sampling variability, c_1 is assumed to be a direct estimate of the parameter c); and p is the probability of guessing correctly on unlearned items and is for the 2-choice group .50 and .25 for the 4-choice group. To discover whether c was constant for varying numbers of reinforcements, individual estimates of c were obtained for each level of reinforcement. If c_1, c_2 . . . c_n refers to the total proportion of items learned after 1, 2, . . . n reinforcements, and c to the constant proportion learned on each reinforced trial, then and so on. These equalities

$$c_1 = c$$

$$c_2 = c (1 - c) + c$$

were written for all 5 reinforcement levels, and for each level individual estimates of c were obtained. The individual estimates of c were then averaged for each choice group separately to obtain an average estimate of parameter c.

Table 17.1. shows estimates of c obtained at each level of reinforcement, for each item group, and for each group of Ss.

In Table 17.1, average c for the 2 choice groups is .3585 and the standard deviation is .1010. Average c for the 4-choice group is .2412 with standard deviation .0685. The average of estimates of c is approximately 10 per cent higher in the 2-choice group than in the 4-choice group. Since both choice groups experienced identical training series in the same room, at the same time, the difference in average c might have resulted from some factor, like response interference, operating during T_1.

As seen in Table 17.1, variability in estimates of c is fairly low in both choice groups; however, it is lower in 4-choice group than in the 2-choice group. Most important, estimates of c for both choice groups appear to meet the assumptions of the model in that they appear to be relatively constant for different levels of reinforcement, and average c appears to be a fair representative of the individual estimates at each level of reinforcement. For both choice groups the distributions of the estimates of c were obtained and they appeared normal. Average c was inserted back into the expression $P = c + (1 - c)$ and was used to generate expected values (P_e) for proportion correct on T_1 after 1, 2, 3, 4, and 5 successive reinforcements.

Figure 17.2 shows the scatter of obtained proportion correct on T_1 (P_o) and predicted proportion correct on T_1 (P_e) after 1, 2, 3, 4, and 5 successive reinforcements. In both the 2-and the 4-choice groups, the points distribute to both sides of the line representing perfect agreement. There seems to be less variability about the line in the 2-choice group than in the 4-choice group. However, variability about the line is, in general, quite low. The average deviation in obtained (P_o) from predicted (P_e) was .03961 in the 2-choice group and .05353 in the 4-choice group. On inspection there appears, then, to be high agreement between obtained and predicted scores. Some indication of agreement was given, however, in Table 17.1 where estimates of c tended to be fairly constant, as they should have been if the model were working, for different levels of reinforcement. There is, however, a slight tendency for observed scores at the higher levels of reinforcement (4 and 5) to be slightly below predictions.

To test the goodness of predictions from the model for varying numbers of reinforcements and for different

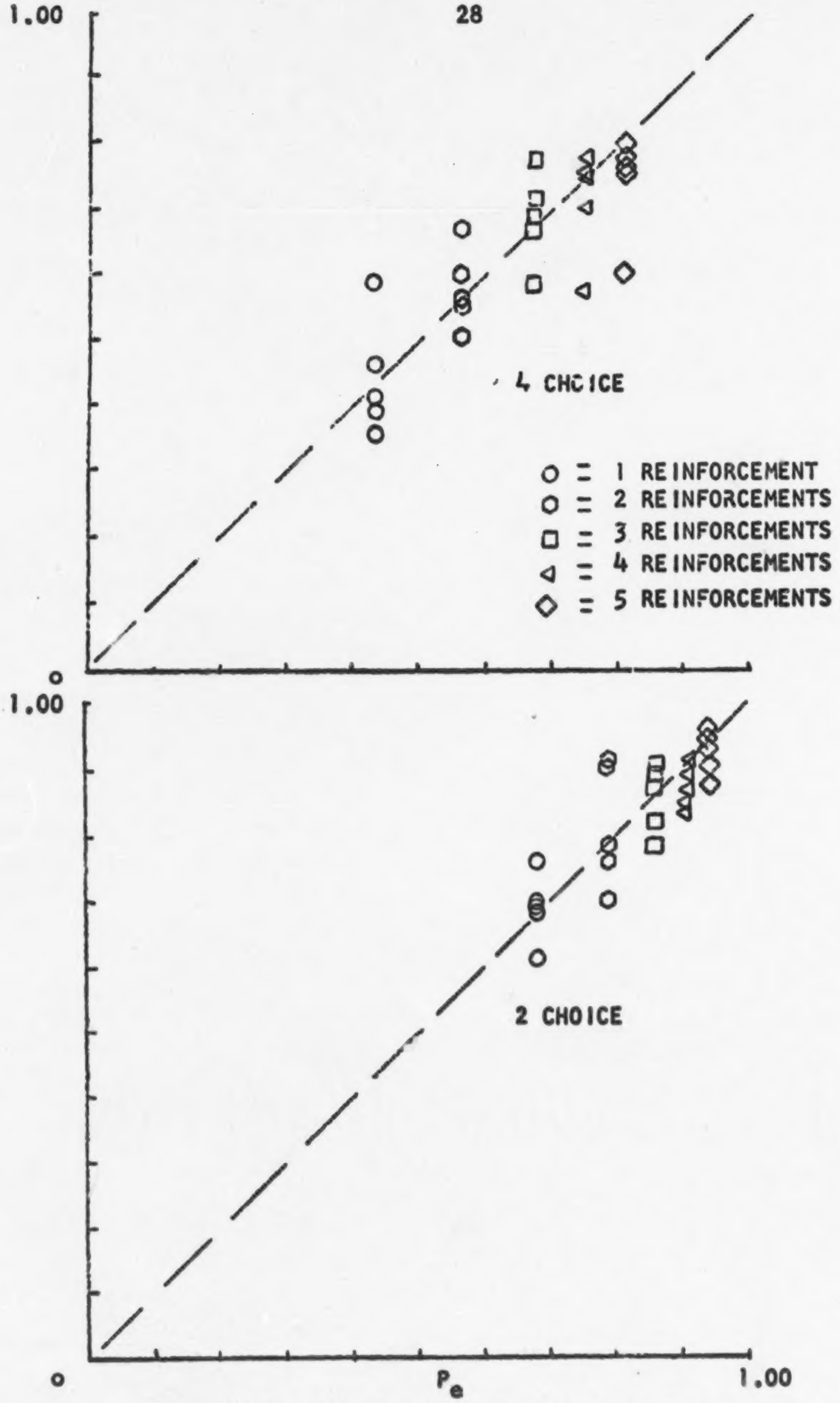


Fig. 17.2. Scatter of Obtained Scores on Predictions for Proportion Correct on T_1.

Table 17.1. Estimates of C for Each Level of Reinforcement

Reinforcement Level	Item Group	Subject Group	Recognition Test	
			2-choice	4-choice
1	A	1	.3667	.4444
	B	5	.2333	.1778
	C	4	.3571	.1538
	D	3	.4167	.2222
	E	2	.5385	.2820
2	A	2	.6078	.3398
	B	1	.3168	.2735
	C	5	.3417	.1972
	D	4	.5774	.2489
	E	3	.2363	.2362
3	A	3	.3700	.2879
	B	2	.2493	.2570
	C	1	.3067	.1779
	D	5	.4496	.3440
	E	4	.4016	.2418
4	A	4	.3852	.2125
	B	3	.2651	.1366
	C	2	.2838	.2552
	D	1	.3313	.2402
	E	5	.2814	.2711
5	A	5	.3317	.2456
	B	4	.2422	.1250
	C	3	.3012	.2260
	D	2	.4013	.2230
	E	1	.3690	.2111
	Mean		.3585	.2412
	Standard Deviation		.10095	.0685

numbers of alternatives on the multiple-choice test, deviation scores ($1+P_o$ P_e to eliminate sign) were inserted into an analysis of variance (already described, p. 14). If, it was reasoned, obtained scores tended to deviate systematically from prediction as a function of reinforcements, the analysis of variance would yield a significant F for reinforcement effects. If the goodness of predictions differed for forms of the multiple-choice test, the analysis would yield a significant F for choice conditions.

Table 17.2 shows the results of the analysis of variance for acquisition. Interactions were tested for homogeneity of variance and the test failed to reach significance. (X^2 was 3.51 and p was greater than .05.) Since the assumption of homogeneity of variance was not rejected, it was assumed that interactions were independent estimates of uncontrolled experimental error. Main effects were, therefore, tested over the appropriate pooled interaction terms. Reinforcement effects, a within-groups effect, were tested over pooled interactions, IR(w), IC, RC, and IRC(w). The test was extremely sensitive, pooled interactions being associated with 32 degrees of freedom. The resulting F was 2.98 and was associated with a p of .05 for 4 and 32 degrees of freedom. The null hypothesis was, therefore, rejected at the .05 level of confidence. Choice effects were not tested ($F < 1.00$).

Since choice effects failed to reach significance, it was assumed that predictions from the model were equally good for the 2-choice test as for the 4-choice test. Although, as seen in Fig. 17.2, deviations of obtained from predicted were very small at all levels of reinforcement, reinforcement effects were found to be statistically significant, and reflect the tendency for 4 and 5 reinforcements to be slightly less effective than predicted by the model. It is difficult to conclude, however, in view of the actual size of the deviations from prediction, that observed and predicted scores do not agree rather well.

Could an incremental theory account for the results that observed scores fell slightly below predictions at the higher levels of reinforcement? Since, for an incremental theory, the strength of S-R associations is assumed to increase with each reinforced trial, an increasing proportion of items would be expected to shift from incorrect to correct after each successive reinforcement. The model's predictions, however, were based on a constant proportion, c, shifting from incorrect to correct after each reinforced

Table 17.2. Analysis of Variance for Deviations in Obtained from Predicted Proportion Correct on T_1.

Source	df	MS	F
Between _Ss_			
Choice (C)	1	.00013	
I x R (b)	4	.00442	
I x R x C (b)	4		
Within _Ss_			
Item Group (I)	4	.01946	
Reinforcement (R)	4	.00707	2.98*
I x R (w)	12		
I x C	4	.00237	
R x C	4		
I x R x C (w)	12		

*P ≤ .05

**P ≤ .01

trial. As seen in Table 17.1, estimates of c were, in fact, fairly constant for different levels of reinforcement. If an incremental theory were more nearly correct, however, individual estimates of c should increase with increasing numbers of reinforcement. Further, if c were increasing with each reinforcement, as an incremental model would expect, then taking an average over the 5 reinforcement conditions would cause predictions to be too high at the 1 and 2 reinforcement levels and too low at the 4 and 5 reinforcement levels. As shown in Fig. 17.2, however, the significance of reinforcement effects was probably due to just the opposite results, i.e., the tendency for predictions to be slightly high at the 4 and 5 reinforcement levels.

Analysis of Responses to "Unlearned" Items

Since for an all-or-none theory, items gotten incorrect represent unlearned items, the model predicts that the likelihood of incorrect items on T_1 shifting to correct on T_2, where no reinforcement intervenes, should be no greater than chance. An incremental theory, however, would assume that incorrect items possess some degree of associative strength, provided at least one reinforcement has been given. The likelihood, therefore, of incorrect items on T_1 shifting to correct on T_2 should be greater than chance. Further, for an incremental theory, since number of reinforcements increases associative strength, the likelihood of incorrect items on T_1 shifting to correct on T_2 should increase with increasing numbers of reinforcements.

Observed proportion QP represented items incorrect on T_1 that shifted to correct on T_2. Dividing QP by Q (observed proportion incorrect on T_1) gave the proportion of incorrect items on T_1 that shifted to correct on T_2. QP/Q was compared with p, the probability of guessing correctly on unlearned items. It was reasoned that if observed QP/Q was larger than p, then more items than expected on the basis of chance alone shifted from incorrect on T_1 to correct on T_2. If, however, QP/Q equalled or was less than p, then only chance proportion of items shifted from incorrect on T_1 to correct on T_2. That is, if QP/Q was less than or equal to p, then proportion of items shifting from incorrect on T_1 to correct on T_2 would represent guessing correctly on unlearned items.

For the 2-choice group, where p was .50, mean proportion QP/Q-p averaged over-all reinforcement levels was - .05236. For the 4-choice group, where p was .25, mean proportion QP/Q-p averaged over all reinforcement levels was + .02888. Since p was subtracted from proportion shifting, zero would represent chance. For both groups, then, average proportion incorrect on T_1 shifting to correct on T_2 is close to chance. In the 2-choice group, the 99 per cent confidence limits of -.05236 were -.18242 and +.07720 and the 95 per cent confidence limits were -.14834 and +.04362. For the 4-choice group the 99 per cent confidence limits were -.02888 were -.04664 and +.10440 and the 95 per cent confidence limits of -.02685 and +.08461. For both groups, then, average proportion of items shifting from incorrect on T_1 to correct on T_2 were not significantly different from chance (zero).

Fig. 17.3 shows proportion QP/Q - p at each reinforcement level for both choice groups. For the 2-choice group, proportion QP/Q - p is well below chance except for the 5 reinforcement condition. In the 4-choice group, proportion QP/Q - p is quite variable, falling above chance after 2, 4, and 5 reinforcements and below chance after 1 and 3 reinforcements. Only at the 5 reinforcement level are both groups above chance.

In order to test whether proportion shifting varied with increasing numbers of reinforcement, or differed for number of alternatives on the recognition test, an analysis of variance was performed. The analysis was performed on 1+ (QP/Q - p) scores; the addition of 1 eliminated differences in sign.

Table 17. 3' shows the results. All interactions were tested for homogeneity of variance and the test failed to reach significance (X^2 was 1.12, p was greater than .05). It was assumed, therefore, that interactions were simply independent estimates of uncontrolled experimental error and, therefore, main effects were tested over appropriate pooled interaction terms.

The choice effect, a between-groups effect, was tested over pooled interactions IR(b) and IRC(b). As indicated by the previous results (i.e., that the confidence limits for both mean proportions had considerable overlap), choice effects were not significant (F was 1.70 and p was greater than .05). Reinforcement effects, a within-groups effect, was tested over pooled

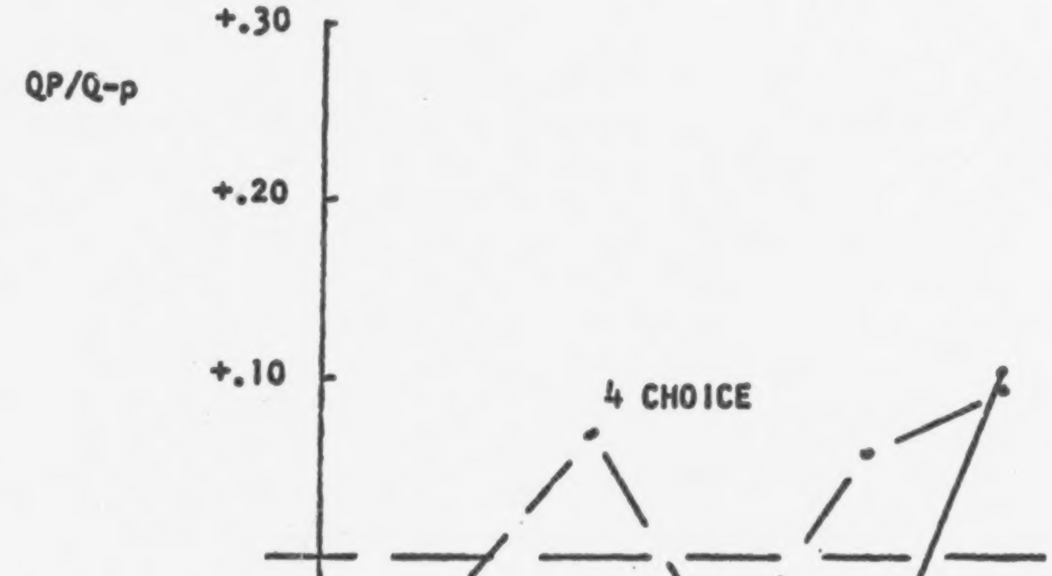


Fig. 17.3. Proportion of incorrect responses on T_1 shifting to correct on T_2, corrected for chance, as a function of numbers of reinforcements.

interaction IR(w) IC RC and IRC(w). The resulting F was 1.85 and was associated with a p greater than .05 for 4 and 32 degrees of freedom. Although both choice groups were above chance at the 5 reinforcement level, the test for reinforcement effects failed to reach significance. It would appear from these results that proportion of incorrect responses on T_1 shifting to correct on T_2 was no greater than chance and further that there was no systematic tendency for proportion shifting to increase with increasing numbers of reinforcements.

Analysis of retention data

Two retention intervals, $T_1 - T_2$ and $T_1 - T_3$, were examined to determine:

(1) whether predictions from the model, based on the assumption of perfect retention of learned items, agreed with obtained retention scores;
(2) or, alternatively, whether retention improved as a function of increasing numbers of reinforcements; and
(3) the effect, if any, of the number of response alternatives on measured retention.

The retention intervals do not represent rest intervals, but simply, for $T_1 - T_2$, the total proportion of responses correct on T_1 that are again correct on the immediately succeeding test, T_2 and, for $T_1 - T_3$, the total proportion of responses correct on T_1 and T_2 that are again correct on T_3.

Predictions for proportion of responses correct on T_1 that are again correct on T_2 ($P\ P_e$) are based on the assumption of perfect retention of items learned. Considering the retention interval, $T_1 - T_2$, no items should be lost, according to the model, going from T_1 to T_2 except a proportion of unlearned items that were guessed correct on T_1. The proportion of items expected to remain correct on T_2, where no reinforcement intervenes between T_1 and T_2, can be expressed as $P\ P_e = c_n + p^2\ (1 - c_n)$ where: $P\ P_e$ is total expected proportion of items correct on T_1 that are again correct on T_2; c_n is total proportion of items learned after n numbers of reinforcements; and p^2 is probability of guessing correctly again on T_2 on unlearned items. p is .50 for the 2-choice group and .25 for the 4-choice group.

Table 17.3. Analysis of Variance for Responses Incorrect on T_1 shifting to Correct on T_2.

Source	df	MS	F
Between $\underline{S}$s			
Choice (C)	1	.08250	1.70
I x R (b)	4	.04849	
I x R x C (b)	4		
Within $\underline{S}$s			
Item Group (I)	4	.06630	
Reinforcement (R)	4	.05078	1.85
I x R (w)	12		
I x C	4	.02744	
R x C	4		
I x R x C (w)	12		

*P ≤ .05

**P ≤ .01

The same assumptions apply to the $T_1 - T_3$ interval. $PPP_e = c_n + p^3 (1 - c_n)$ where: PPP_e is total proportion of items correct on T_3 that were also correct on T_1 and on T_2; and p^3 is the probability of guessing correctly a third time on unlearned items.

It can be seen from these expressions that PP_e and PPP_e include all items learned during training. The implications of such a model are that retention reflects amount learned during training and does not improve increasing amounts of reinforcement. The equations were used to obtain expected values of PP_e for the $T_1 - T_2$ retention interval and PPP_e for the $T_1 - T_3$ interval, by subtracting out the guessing factor, $p^2 (1 - c_n)$ for PP_e and $p^3 (1 - c_n)$ for PPP_e.

Figure 17.4 for the $T_1 - T_2$ retention interval, shows the scatter of obtained and predicted scores for both choice groups at each reinforcement level, about the line representing perfect agreement. The plots for both choice groups show that obtained scores approach and exceed predictions for the one reinforcement condition, and tend to fall somewhat short of predictions for the higher levels of reinforcement (2, 3, 4, and 5). Scores at the higher levels of reinforcements (2, 3, 4, and 5) appear, however, to fall some fairly constant amount below predictions. Further, as shown in Fig. 17.4, scores for the 2-choice group fall slightly closer to the line representing perfect agreement than scores for the 4-choice group. For both groups, however, observed and predicted scores appear to be in fairly high agreement with predictions. That is, except for the 1 reinforcement condition, which appears to be in perfect agreement with predictions, reductions below predicted level, although present, appear to be roughly constant over the 2, 3, 4, and 5 reinforcement range.

Figure 17.5, for the $T_1 - T_3$ retention interval, shows much the same general pattern of variability. Obtained scores for the 2, 3, 4, and 5 reinforcement series fall below the line representing perfect agreement, while obtained scores for the 1 reinforcement condition approach or fall above the line representing perfect agreement. Here, as in Fig. 17.4 reductions below prediction appear to be fairly constant over the 2, 3, 4, and 5 reinforcement range. In the 4-choice group, obtained scores for the higher levels of reinforcement (2, 3, 4, and 5) are further below the line of perfect agreement

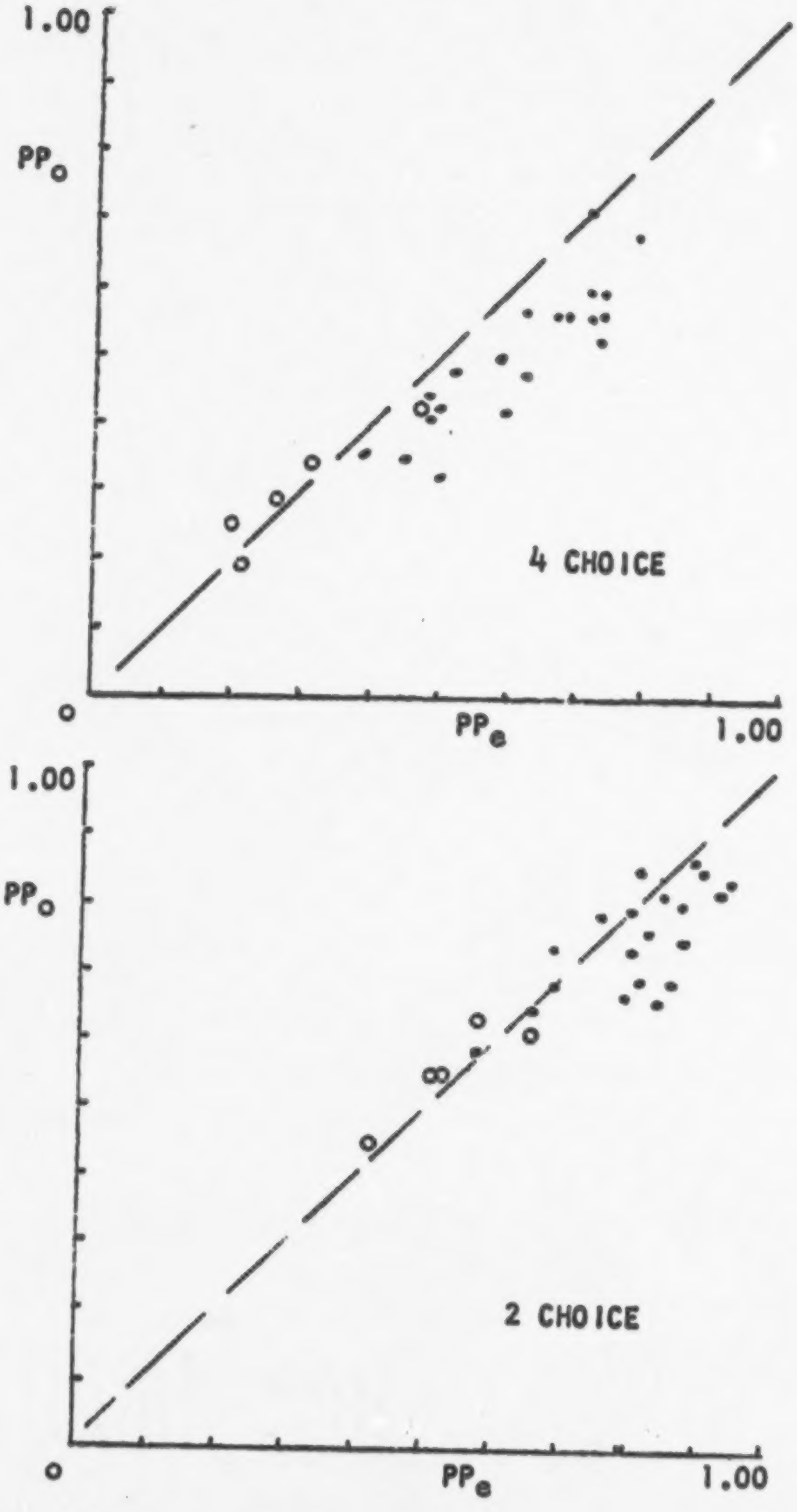


Fig. 17.4. Scatter of obtained scores on predicted for proportion of items correct on both T_1 and T_2. The one reinforcement points were plotted as open circles. Higher levels of reinforcement showed no pattern and are not distinguished within the Figure.

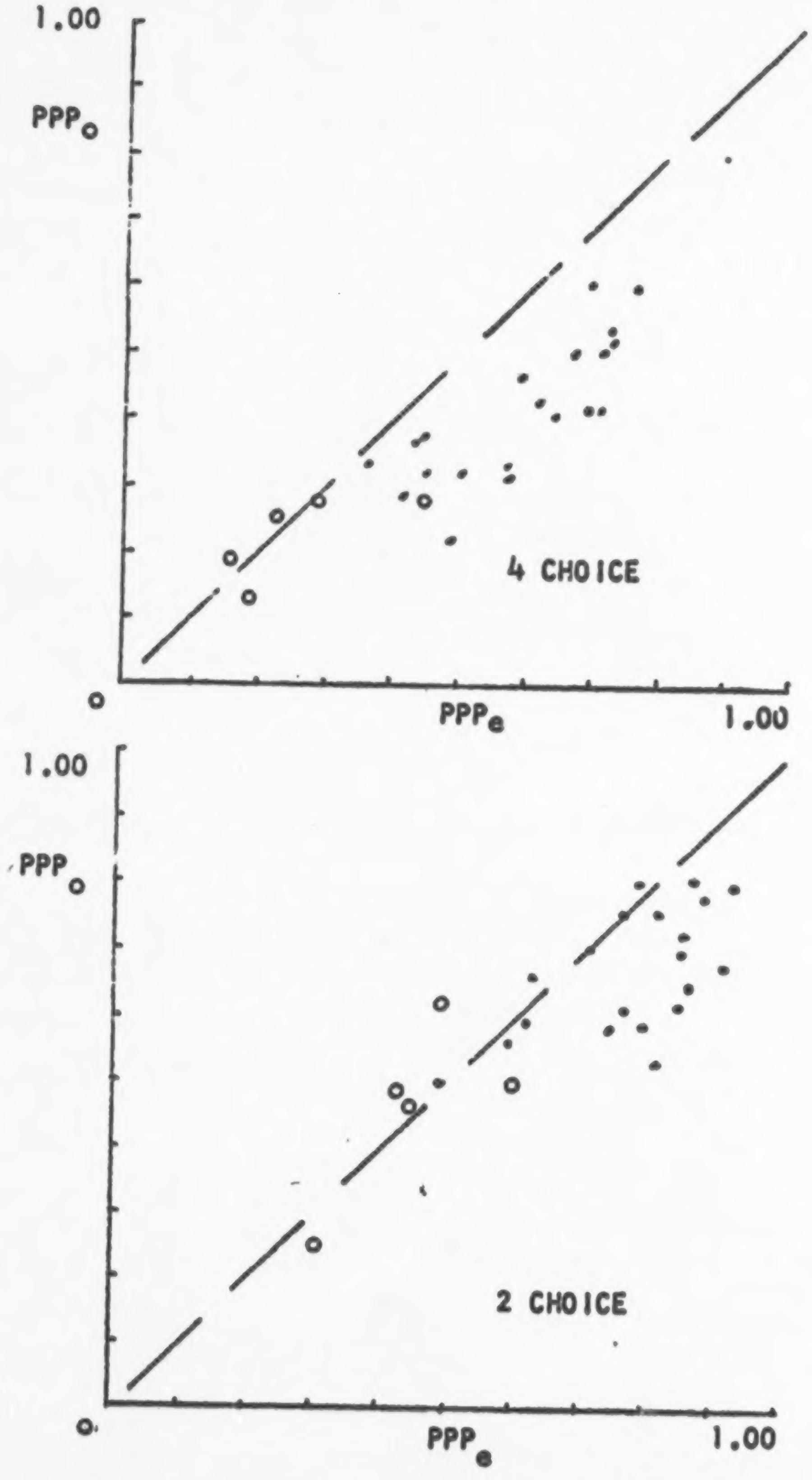


Fig. 17.5. Scatter of obtained scores on predicted for proportion of items correct on T_1, T_2 and T_3. The one reinforcement points were plotted as open circles. Again, higher levels of reinforcement showed no pattern and are not distinguished within the Figure.

than corresponding obtained scores for the 2-choice group. Further, scores for both the 2-and 4-choice group, however, are slightly further below predictions than corresponding scores for both groups on the $T_1 - T_2$ interval in Fig.17.4.

Except for differences between one reinforcement and the higher levels of reinforcement on both retention intervals, the observed scores appear to agree fairly well with predictions. In order to have a precise test of whether retention improves with number of reinforcements or with number of alternatives on the recognition test, an analysis of variance was performed on proportion retained. Proportion retained was based on the model's predictions of perfect retention and was $P\,P_o/P\,P_e$ for the $T_1 - T_2$ interval and $P\,P\,P_o/P\,P\,P_e$ for the $T_1 - T_3$ interval.

In order not to extend the assumption that interactions were not significant further than necessary, separate analyses were performed on each retention interval. Table 17.4 shows the results of the analysis of variance for the $T_1 - T_2$ retention interval. Interactions were tested for homogeneity of variance and the test failed to yield significant results (X^2 was 5.29 and p was greater than .05). Main effects were, therefore, tested over their respective pooled interaction terms. The critical aspect of the test for reinforcement effects was to be able to specify where differences in retention, if any, were to be found among the 5 reinforcement levels. Therefore, planned orthogonal comparisons were used in place of an overall test of reinforcement effects.

Table 17.4 shows main effects for reinforcements broken into 4 orthogonal comparisons, each associated with 1 degree of freedom. Since reinforcements is a within-groups effect, the comparisons were tested over pooled interactions IR(w), IC, RC, and IRC(w). Comparisons between the 2 and 3 versus the 4 and 5 reinforcement levels and comparisons between the 2 versus the 3 reinforcement level were not tested since F was less than 1.00. The comparison between the 4 and 5 reinforcement level yielded an F of 1.85 which, associated with p greater than .05 for 1 and 32 degrees of freedom, was not significant. The comparison between the 1 reinforcement level and all other levels of reinforcement (1 versus 2 + 3 + 4 + 5) yielded an F of 23.26 which, associated with a p of

Table 17.4. Analysis of Variance for Retention on $T_1 - T_2$ Retention Interval.

Source	df	MS	F
Between Ss			
Choice (C)	1	.11150	9.49*
I x R (b)	4	.01175	
I x R x C (b)	4		
Within Ss			
Item Group (I)	4	.01960	
Reinforcement (R)			
1 versus (2+3+4+5)	1	.15934	23.26**
2+3 versus 4+5	1	.00010	
4 versus 5	1	.01270	1.85
2 versus 3	1	.00205	
I x R (w)	12		
I x C	4	.00686	
R x C	4		
I x R x C (w)	12		

*P ≤ .05

**P ≤ .01

less than .01 for 1 and 32 degrees of freedom, was significant.

The results show that amount retained after a single reinforcement differed significantly from amount retained at all other reinforcement levels. Comparisons among higher reinforcement levels, however, failed to yield significant results. The results of the comparison presumably reflect the outcome, seen in Fig. 17.4 that retention was particularly high (at predicted level) after 1 reinforcement and some fairly constant amount below predictions at all other levels of reinforcement.

The choice effect, a between-groups effect, was tested over pooled interactions IR(b) and IRC(b). F was 9.49 and was associated with a p of less than .05 for 1 and 8 degrees of freedom. Since p was less than .05, the null hypothesis was rejected. Since only two means were compared, the results indicate that retention was better in the 2-choice group than in the 4-choice group.

Table 17.5 shows the results of the analysis of $P\,P\,P_o/P\,P\,P_e$ scores for the $T_1 - T_3$ retention interval. Interactions were tested for homogeneity of variance and the test failed to attain significance. (X^2 was 3.87 and p was greater than .05). Main effects were, therefore, tested over their respective pooled interaction terms. Rather than perform an overall test of reinforcement effect, planned orthogonal comparisons were again used, and all comparisons were tested over pooled interactions IR(w), IC, RC, and IRC(w). Table 17.5 shows that, as for the $T_1 - T_2$ interval, only the comparison between the one reinforcement condition and all other levels of reinforcement reached significance. F was 14.34 and was associated with a p of less than .01 for 1 and 32 degrees of freedom. Comparisons among all higher levels of reinforcement failed to reach significance. Choice effects, a between-groups effect, were tested over pooled interactions IR(b) and IRC(b). F was 14.58 and was associated with a p of less than .01 for 1 and 8 degrees of freedom. Since p was less than .01, the null hypothesis was rejected.

The results for the $T_1 - T_3$ interval are similar to the results for the $T_1 - T_2$ interval. On both intervals, retention after a single reinforcement is particularly high and in high agreement with

Table 17.5. Analysis of Variance for Retention on the $T_1 - T_3$ Retention Interval.

Source	df	MS	F
Between Ss			
Choice (C)	1	.29776	14.57**
I x R (b)	4	.02043	
I x R x C (b)	4		
Within Ss			
Item Group (I)	4	.06274	
Reinforcement (R)			
1 versus (2+ 3+ 4+ 5)	1	.20128	14.34**
2 + 3 versus 4+ 5	1	.00010	
2 versus 3	1	.00030	
4 versus 5	1	.01705	1.21
I x R (w)	12		
I x C	4	.01404	
R x C	4		
I x R x C (w)	12		

$*P \leq .05$

$**P \leq .01$

predictions from the model. Retention at all other levels of reinforcement, however, is lower than retention after a single reinforcement, falling some fairly constant amount below predictions. Further, over both retention intervals, retention is better in the 2-choice group than in the 4-choice group.

The results for both the $T_1 - T_2$ and $T_1 - T_3$ retention intervals, that retention is particularly high after one reinforcement and stands out from the other reinforcement levels, is not specifically expected by either an incremental or an all-or-none theory. The results that there were no differences in retention for all higher levels of reinforcement indicates that retention did not improve with increasing numbers of reinforcements. As shown in Fig. 17.4 and Fig. 17.5, for the $T_1 - T_3$ intervals, respectively, retention tended to be lower than, but fairly linear with, predictions at all higher levels of reinforcement. This result, that retention, although lower than predictions, did not improve with increasing numbers of reinforcements, is consistent with an all-or-none theory.

Significant choice effects indicates, since only two means were compared, that retention was better for Ss given the 2-choice test than for Ss given the 4-choice test. Since both groups experienced identical training series, in the same room, at the same time, it would appear that differences in retention between the groups resulted from factors operating on the test rather than during training. A tentative interpretation is that response interference occurs on the multiple-choice test and is greater for greater numbers of alternatives. The 4-choice group would then undergo more response interference than the 2-choice group. This could account for the poorer retention of the 4-choice group on both the $T_1 - T_2$ and $T_1 - T_3$ retention intervals.

Results for T_1 showed similar effects. Average c (estimated proportion learned on each trial) was lower for the 4-choice group than for the 2-choice group. Since estimates of c were taken from T_1, it is possible that interference occurred on T_1 causing the estimates to be lower for the 4-choice group than for the 2-choice group. Further, estimates of c would essentially correct for interference on T_1 in that c was used to predict retention on subsequent tests. The result that the 4-choice group is further below prediction, based on a lower value of c, than the 2-choice group, indicates that T_2 provided its own source of retention loss and was not simply reflecting initial differences on T_1. Test 3 also appeared to produce further retention losses. As seen in comparing Figs. 17.4 and 17.5, retention in both groups at all higher levels of reinforcement was slightly further below predictions on the $T_1 - T_3$ interval than on the

T_1 - T_2 interval. A second source of retention loss, then, tentatively interpreted as resulting from response interference, is from successive administrations of the recognition test.

An incremental theory would expect that increasing amounts of reinforcement which strengthens S-R connections would reduce the possibilities of interference at the higher levels of reinforcement. An all-or-none theory would expect, however, since S-R connections are formed on a single trial and not affected by subsequent reinforcements, that the opportunities for the learning of interfering responses would be equal at all levels of reinforcement. The data are more consistent with an all-or-none theory in that retention at all higher levels of reinforcement did not improve with increasing numbers of reinforcements.

Analysis of All-or-None Versus Partial Forgetting

This analysis is based on the assumption that items correct on T_1, but incorrect on T_2, have a better than chance likelihood of being correct again on T_3 if forgetting occurs to intermediate degrees, and have only chance or less likelihood of being correct again on T_3 if forgetting is complete. If forgetting is complete, then according to the model proportion PQ (items correct on T_1 but incorrect on T_2) would simply be multiplied by chance (p, the probability of guessing correctly on unlearned items) to obtain expected proportion PQP on T_3. A test for all-or-none forgetting, then, is that the observed proportion PQP/PQ should be equal to or less than p. If forgetting occurs to an intermediate degree and forgotten items can be recalled, then proportion PQP/PQ should exceed p. Proportion PQP/PQ was taken directly from the data. p was, as before, a priori determined as .50 for the 2-choice and as .25 for the 4-choice group.

Based on 82 observations, mean observed proportion PQP/PQ - p averaged over all 5 reinforcements series was +.04148 for the 2-choice group and based on 84 observations, mean proportion PQP/PQ - p was +.09888 for the 4-choice group. If proportion of items in state PQ on T_2 shifting to correct (PQP) on T_3 represented chance or less, then proportion PQP/PQ - p should be at or around zero. In order to test if the true population mean proportion PQP/PQ - p could be zero, confidence limits were obtained for both proportions. The 99 per cent confidence limits for +.04148 in the 2-choice group were —.12326 and +.20622. Since the lower limit easily includes zero, observed proportion .04148 could have come from a population with mean proportion representing chance. The 95 per cent limits, representing a narrower range, were also found

5

to include zero (—.08009 and +.16305). For the 4-choice group, however, the 99 per cent confidence limits of +.09888 were +.00350 and +.19426. Here, the lower limit falls slightly above zero. Similarly, the 95 per cent limits for this proportion also lie above zero, representing chance, at +.02850 and +.16926. For the 4-choice group, then, mean proportion PQP/PQ - p could be significantly higher than chance. Since the limits for proportions, .04148 and .09888, overlap, both proportions could have come from a population having the same mean. This possibility and the possibility that proportion PQP/PQ - p varied with increasing numbers of reinforcements was tested in an analysis of variance.

Table 17.6 shows the results of the analysis of (1+ PQP/PQ - p) scores. Mean squares for interactions were higher than mean squares for reinforcement effects. It appeared, however, that there were no systematic interaction effects, but that proportion PQP/PQ - p was highly variable. A test for homogeneity of variance of interactions failed to reach significance (X^2 was 1.09; p was greater than .05).

Choice effects, a between-groups effect, was, therefore, tested over pooled interaction IR(b), IRC(b). F was 1.21 and was not significant (p was greater than .05 for 1 and 8 degrees of freedom). As indicated by this test, and previously by the overlapping confidence limits, mean proportion PQP/P - p in both choice groups appeared to have come from a population having the same mean. Further, since the limits overlapped above zero, this mean is close to, but probably slightly above, chance. Since mean squares for interactions was larger than mean squares for reinforcements, no test was actually run. This indicates that proportion PQP/PQ - p for different reinforcement levels was highly variable, but that there was no systematic effect for reinforcements (i.e., proportion PQP/PQ - p did not increase with increasing numbers of reinforcements).

The result that mean proportion PQP/PQ - p may be slightly greater than chance counterindicates a theory of all-or-none forgetting. The result, however, that proportion PQP/PQ -p did not increase with increasing numbers of reinforcements is consistent with the theoretical model and the finding, reported earlier, that retention does improve with number of reinforcements.

Discussion

An all-or-none theory generates a simple model for paired-associates learning measured by multiple-choice tests. Specifically,

PRECEDING PAGE BLANK-NOT FILMED

it is reasonable to assume that a constant proportion (c) of unlearned items are learned on each reinforced trial, and that the likelihood of guessing correctly (p) and incorrectly (q) can be evaluated from the number of alternatives. These quantities, c, p, q, of which only one (c) is determined from data, are sufficient to generate predictions for acquisition and retention over a wide range of conditions.

Generally, the predictions generated from the model gave a good fit for the present data. For acquisition, individual estimates of c were found to be fairly constant over all levels of reinforcement. Although the analysis of variance, which was used to test the goodness of predictions based on an average c yielded a systematic effect, i.e., the tendency for scores at the 4 and 5 reinforcement levels to fall slightly below predictions, the size of all deviations from prediction were exceedingly small. An incremental theory, however, could not account for the effect because it would predict opposite results, i.e., a tendency for observed scores to be above predictions at the higher levels of reinforcement. The present results for acquisition were, therefore, considered to be, in general agreement with predictions from the model and supporting the results of Estes et al. (1960) where it was possible to fit the model for up to z reinforcements.

Since recent investigators Battig (1962) and Battig and Birtcher (1962) showed for Rock's technique that differential item difficulty counteracted the effects of reinforcement, it was considered, for the present study, that differential item difficulty could have been associated with similar effects. Differences in item difficulty could, within an incremental theory, yield a constant c through the rapid growth of habit for easy S-R pairs early in training and the later slower development of habit for more difficult

S-R pairs. In order to determine whether this could, in fact, have occurred, 3 levels of item difficulty (high, medium, and low) were examined and growth functions plotted for each number of alternatives. The results were that the functions for all the levels of difficulty had rising slopes and extremely easy and hard items were reasonably well fitted by estimates of c.

A second test of the model was made by examining incorrect responses to items. The results were in agreement with Estes et al., (1960) inshowing that response shifts from incorrect on T_1 to correct on T_2 could be attributed to guessing on unlearned items. Further, the results showed that there was no systematic effect for different levels of reinforcement, i.e., that proportion shifting from incorrect to correct did not increase with increasing numbers of reinforcements. These results indicate, therefore, that for up to 5 reinforcements the correct response, if the item was incorrect on T_1, was no more likely to occur on T_2 than responses never reinforced during training. Since an incremental theory predicts that associative strength for all items increases with increasing numbers of reinforcements, this is a highly unfavorable result for such a theory. That is, items reinforced 3, 4, and 5 times could reasonably be expected to possess considerable associative strength and should, therefore, have some probability greater than chance, of being correct on T_2. These results, however, would appear to indicate that, as predicted by the model, incorrect items had negligible associative strength.

The possibility was again considered that this finding could have resulted from particularly difficult items being represented in the sample of incorrect items. As already noted, the growth functions for all 3 levels of item difficulty, however, had rising slopes indicating that no items were particularly resistant to learning. Further, the functions showed that all items were above chance after the second reinforcement. It would appear, then, that the present findings for proportion shifting cannot be attributed to item difficulty.

Another possibility was that proportion of incorrect responses on T_1 shifting to correct on T_2 could be effected by "learning" on the test itself, i.e., that any response, correct or incorrect, given to an item on T_1 could acquire a higher than chance probability of recurring on T_2. Such an effect could conceivably mask the effects of previous reinforcements on the correct response. To determine the effect of a test trial, tabulations were made of instances in the 4-choice test, where incorrect responses on T_1 were repeated on T_2 (by the same S). For 208 cases, it was found that the effect of giving a particular incorrect response on T_1 was to raise its probability of occurrence on T_2 from chance (.25 assuming no learning occurred during training, and all 4 responses to an incorrect item were equally likely) to around .44. Some "learning," therefore, apparently did occur. Estes et al. (1960) also found evidence for "learning" on the test trial itself. They found that particular incorrect responses tended to persevere over as many as 4 successive tests. In order, however, to interpret this effect as an argument for an incremental theory it would be necessary to assume that a single test trial, in determining which response, correct or incorrect, occurs on the next test trial, masks the effects of up to 5 reinforcements of the correct response.

The results for retention showed that, except after one reinforcement where retention was at the predicted level, retention for higher levels of reinforcement was a constant amount below predictions. The analysis showed that increasing the number of reinforcements did not improve retention. These results support the results of Estes et al. (1960) that retention was no better after two than after a single reinforcement. They are also in agreement with the more recent findings of Murdock and Babick (1961) for meaningful material, that repetition did not improve retention of individual words. The finding that retention does not improve with increasing numbers of reinforcements is predicted by the model and consistent with a theory of all-or-none learning, which predicts that retention of correct items should not depend on the number of times an item is reinforced, and not with an incremental theory which predicts that retention should improve the greater the number of reinforcements.

In attempting to evaluate how retention losses occur, specifically, by giving two forms of a multiple-choice recognition test, the present study found that retention losses at the higher levels of reinforcement were a function of successive administrations of the recognition test and the number of choices on the test. A previous unpublished study by Griffith and Griffith (1960) which employed similar learning materials for a single training trial on an 8-item paired-associates list, found, as did the present study, that retention was better in the 2-choice group. They also found, as did the present study, that estimates of c obtained on T_1 were higher for the 2-choice group than for the 4-choice group. Both sets of data appear to support a conclusion that retention losses result, in part at least, from the learning of interfering responses on the multiple-choice recognition test.

If interference was a factor responsible for retention losses, an incremental theory would expect that interference would be less, the greater the amount of previous training; i.e., the stronger the S-R association as established by reinforcement. According to the present results, however, reinforcement was not all effective in improving retention. Rather, retention in both choice groups, on both retention intervals, remained some fairly constant amount below predictions for increasing numbers of reinforcements. According to an all-or-none theory, however, since learning is complete on a single trial, and subsequent trials do not affect the strength of already-established associations, interference should be equally likely at all levels of reinforcement. The data that retention does not improve with increasing amounts of reinforcement are, therefore, in agreement with an all-or-none interpretation.

The results on whether forgetting is all-or-none or occurs to intermediate degrees were mixed. On the one hand, the results were consistent with the results of Estes et al. (1960) in showing that, on the average, recall of forgotten items was above chance. The Estes et al. estimate of chance, however, assumed that Ss guessed, on unlearned items, from among all response members on the paired-associates list. Since it is unlikely, however, that Ss guessed from among items already learned during training, a better estimate could have been considerably higher.

The two sets of results, therefore, tend to favor a theory that forgetting occurs to intermediate degrees. An incremental theory would predict that forgetting need not be complete in that reductions in associative strength could reasonably be expected to occur to any degree. Because learning is assumed to be a discontinuous, an all-or-none theory would predict that forgetting represents complete loss of the response. These results for forgetting, therefore, tend to favor an incremental theory. However, in the present study, and also possibly in the study of Estes et al., recall of forgotten items was not very much above chance.

The possibility was considered that these results simply represented "sequential" effects (i.e., the possibility that any response, correct or incorrect, occurring on T_1 could acquire a higher than chance probability of recurring again on a later test). Therefore, for the 4-choice group, cases were examined where a particular wrong response was given on T_1, followed by a different wrong response on T_2 and a recurrence of the original wrong response on T_3. The result for these cases was in the neighborhood of chance (p was .28 where chance on the 4-choice test was .25). The actual number of cases involved in the count (38), however, was considered too small to be reliable. The possibility, therefore, that the present results simply represent "sequential" effects cannot be reliably ruled out.

If forgotten items can be recalled again, for reasons given by an incremental theory, then, like retention, recall should depend on associative strength and should increase with increasing numbers of reinforcements. The results showed, however, that although proportion recalled on T_3, after being correct on T_1 and incorrect on T_2, was highly variable for different levels of reinforcement, there was no systematic tendency for proportion recalled to increase with numbers of reinforcements. In this respect, the results are consistent with the retention data, in that retention, also, did not improve with increasing amounts of reinforcement, and are more consistent with an all-or-none than with an incremental theory.

Summary

The present study tested predictions from an all-or-none model for the learning of paired-associates. The model was used to predict acquisition and retention data for up to 5 successive reinforcements and for 2 forms (2-and 4-choice) of a multiple-choice recognition test. For acquisition, the results showed that the model, which assumes that a constant proportion of items are learned on each reinforced trial, was able to give a fairly accurate description of the actual data for up to 5 successive reinforcements. The results also showed that response shifts from incorrect on T_1 to correct on T_2 could be attributed to guessing on unlearned items, and further, that the likelihood of response shifts does not increase with increasing numbers of reinforcements.

For retention observed scores fell slightly below predictions, except at the one reinforcement level. However, reductions in observed scores remained fairly constant for all

higher levels of reinforcement; i.e., retention did not improve with increasing numbers of reinforcements. Retention losses appeared to be a function of number of response alternatives and successive administrations of the recognition test. Retention losses were tentatively interpreted as resulting from response interference on the multiple-choice recognition test.

The results on the nature of forgetting (i.e., whether forgetting occurs to intermediate degrees or is all-or-none in nature) tended to favor the view that forgetting is partial. Proportion of items recalled on T_3, however, was not very far above chance and it was not entirely possible to rule out the alternative that this simply represented a "sequential" effect. The results for forgetting showed, however, that the likelihood of recalling forgotten items did not increase with increasing numbers of reinforcements.

As a test of the model, these results were considered as giving the model considerable support. In all analyses there was opportunity for a reinforcement effect to appear, and in no case did one appear which could be considered evidence for an incremental theory. The model, however, was found to be inadequate in specifying conditions, specifically, the number of reinforcements, under which retention losses occur and in accounting for recall of forgotten items. Estes found similar problems with the model and suggested tentative explanations involving changes in the stimulus. Since the present study neither tested nor controlled for variations in the stimulus and its context, no similar speculations were offered. For the issue of all-or-none versus incremental learning, the results are interpreted as supporting the view that learning occurs on an all-or-none basis, repeated reinforcements operating to allow the discontinuous formation of learned associations.

References

Battig, W. F. Paired-associate learning under simultaneous repetition and non-repetition conditions. J. Exp. Psychol., 64, 1962, in press.

Battig, W. F., and Birtcher, D. Effect of kind of material and previous experience on paired-associate learning under repetition and non-repetition conditions. Unpublished manuscript.

Brackett, H. R. The effect of pretraining and knowledge of results on the acquisition of paired-associates. Unpublished master's thesis, University of Virginia, 1961.

Brackett, H. R., and Battig, W. F. Method of pretraining and knowledge of results in paired-associate learning under repetition and non-repetition conditions. Unpublished manuscript.

Bush, R. R., and Mosteller, F. Stocastic Models for Learning. New York: Wiley, 1955.

Clark, L. L., Lansford, T. G., and Dallenbach, K. M. Repetition and Associative Learning. Amer. J. Psychol., 1960, 73, 22-40.

Estes, W. K. Toward a statistical theory of learning. Psychol. Rev., 1950, 57, 94-107.

Estes, W. K. Component and pattern models with Markovian interpretation. In R. R. Bush and W. K. Estes (Eds.), Studies in Mathematical Learning Theory, Stanford: Stanford University Press, 1959, Pp. 9-52.

Estes, W. K. Learning theory and the new "mental chemistry." Psychol. Rev., 1960, 67, 207-223.

Estes, W. K., Hopkins, B. L., and Crothers, E. J. All-or-none and conservation effects in the learning and retention of paired-associates. J. Exp. Psychol., 1960, 60, 329-339.

Forrest, D. W. Auditory familiarity as a determinant of visual threshold. Amer. J. Psychol., 1957, 70, 634-636.

Guthrie, E. R. The Psychology of Learning. New York: Harper, 1935.

Hovland, C. I. Human learning and retention. In S. S. Stevens (Ed.), Handbook of Experimental Psychology. New York: Wiley & Sons, 1951, Pp. 613-689.

Hull, C. I. Principles of Behavior. New York: Appleton-Century, 1943.

King-Ellison, P., and Jenkins, J. J. Durational threshold of visual recognition. Amer. J. Psychol., 1954, 67, 700-703.

Lockhead, G. R. A re-evaluation of evidence of one-trial associative learning. Amer. J. Psychol., 1961, 74, 590-595.

Lindquist, E. F. Design and Analysis of Experiments in Psychology and Education. Boston: Houghton Mifflin, 1956.

Murdock, B. B., Jr., and Babick, A. J. The effect of repetition on the retention of individual words. Amer. J. Psychol., 1961. 74, 596-601.

Postman, L. Repetition and paired-associate learning. Amer. J. Psychol., 1962, 75, in press.

Rock, I. The role of repetition in associative learning. Amer. J. Psychol., 1957, 70, 186-193.

Rock, I., and Heimer, W. Further evidence of one-trial associative learning. Amer. J. Psychol., 1959, 72, 1-16.

Underwood, B. J., Rekula, R., and Keppel, G. Item selection in paired-associates learning. Amer. J. Psychol., 1962, 76, in press.

Underwood, B. J., and Schulz, R. W. Meaningfulness and Verbal Learning. Chicago: J. B. Lippincott & Co., 1960.

Chapter 18

Knowledge of Results and Tangible Reinforcement in Automated Instruction

Michael J. M. East, R. J. Capobianco,

David L. Hoats and Malvin Gelof

The purpose of the present study was to determine whether tangible reinforcement would improve teaching machine learning in retardates and, further, whether partial, tangible reinforcement would be even more effective than 100% tangible reinforcement, as might be assumed from the experimental work of Spradlin (1963), and Stevenson and Zigler (1958).

Procedure

Apparatus

A teaching machine which was produced by Johnstone Training and Research Center and Biophysical Electronics, Inc.,[1] was the basic piece of apparatus used. A detailed description of the machine can be found in a report by Blackman and Holden (1963). In brief, the machine is a two-channel, audio and visual device, designed for the teaching of beginning reading and arithmetic. It uses linear, multiple choice programs on 35 mm filmstrips and magnetic recording tape. Immediate feedback or knowledge of results (K/R) is provided by the flashing of a green light following correct responses and a red light following incorrect responses.

In addition, an MMD-1 M & M candy dispensing machine, produced by Davis Electronic, Inc. of Studio City, California, was attached to the teachine machine to automatically provide tangible reinforcement for the experimental groups. Figure 18.1 is a photograph of the teaching machine with the M & M dispenser attached.

The teaching machine is equipped with a readout jack which normally would be used to feed response data to a recording instrument. In this study the jack was used to operate the M & M dispenser, so that it was necessary for an E to observe and record each of Ss' responses.

Program

The four words presented by the experimental program were: about, one, food, and could. These words were selected at random from Thorndike's (1944) list of 30,000 words. It may be seen that the choices

---

[1] Now operating under the name of Bionics Instruments, Inc. in Philadelphia, Pennsylvania.

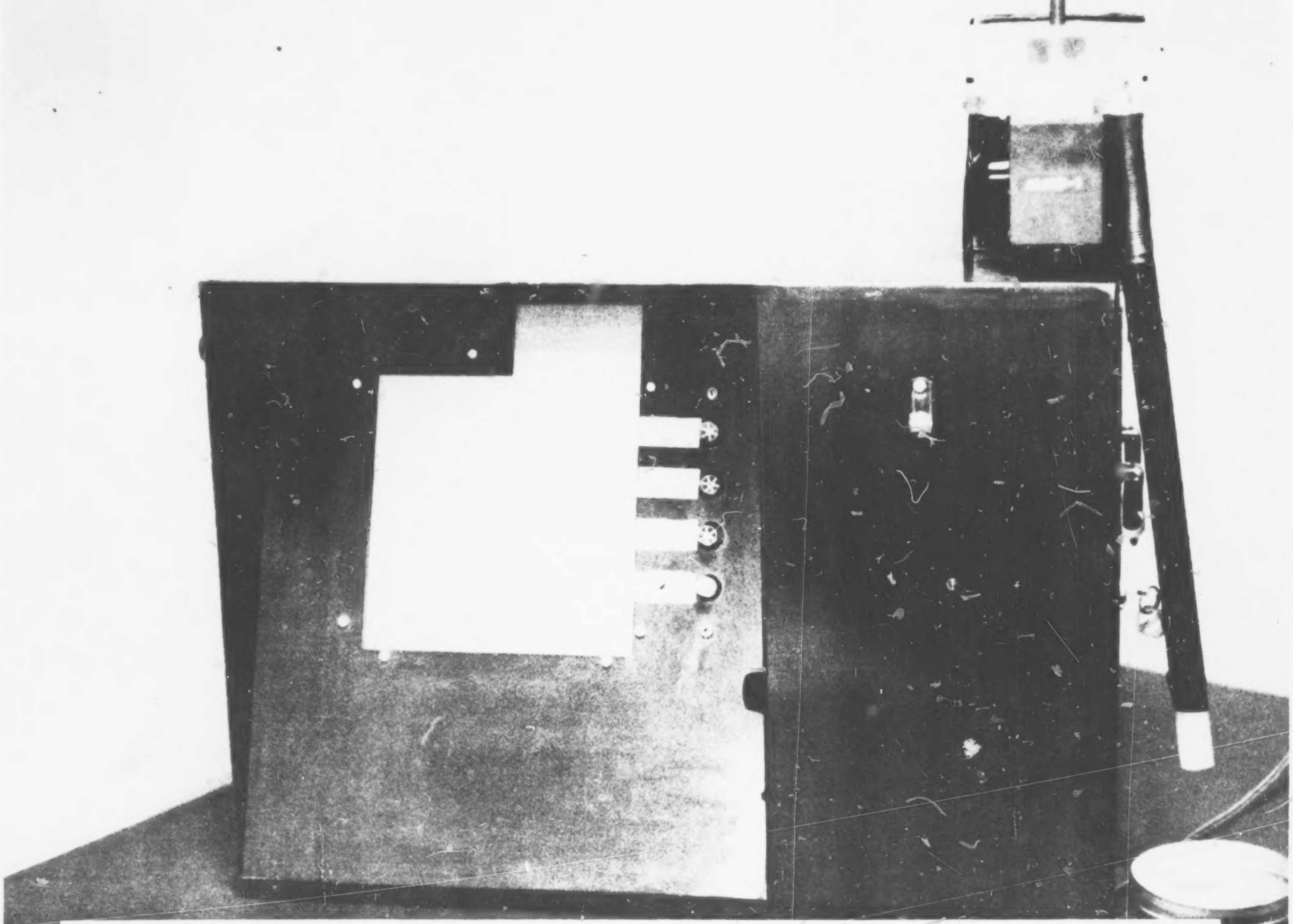


Fig. 18.1. The Teaching Machine with the M & M dispenser attached.

are not phonetically consistent and, in all probability, were learned as sight words.

The experimental program is one in which three types of frames are used. These range from maximal support to minimal support and are arranged through the program so that the support is gradually faded for each word. In the maximal support frame, S sees the four alternatives arranged next to the buttons on the right side of the viewing screen. S is also presented with the correct alternative on the left side of the screen. The word on the left is underlined. In order for S to choose the correct alternative from the list next to the buttons, he need only compare the four choices with the word on the left. Figure 18.2 is a reproduction of the visual portion of a maximal support frame.

The audio portion accompanying this frame is as follows: "Look at the word by itself, that word is food. Look at the four words next to the buttons. The word on top is food. The next word is about. The next word is one. And the word on the bottom is could. Press the button next to the word food."

On the second type of frame, the word on the left of the screen is dropped. Reference to it in the audio presentation is also deleted; however, all four alternatives are still read as in the maximal support frame. The third type of frame includes no prompting material. S is instructed by the tape: "Press the button next to the word________."

Each of the four words is presented several times under each of the support conditions. The correct and incorrect alternatives in each frame are randomized. The first eight frames consist of two maximum support presentations of each of the four words. This is followed by three maximum support presentations of the first word then two medium support presentations of the first word and finally two minimum support presentations of the first word. This sequence; 3 max. -- 2 min. is then repeated for each of the three remaining words in order. The last eight frames (test frames) are two minimum support presentations of each word with the order of word presentation randomized.

Subjects

Thirty mentally retarded adolescent males with little or no reading ability were chosen from the population of the Johnstone Center. This included almost all students classified as non-readers at Johnstone and no Ss classified as readers. Only those Ss were used who did not know the four words to be taught by the experimental program. These Ss were then divided into three groups of ten, matched on the basis of chronological age, intelligence quotient, and reading achievement. IQ scores were determined by the Wechsler Intelligence Scale for Children (Wechsler, 1948). Reading achievement scores were obtained on the Metropolitan

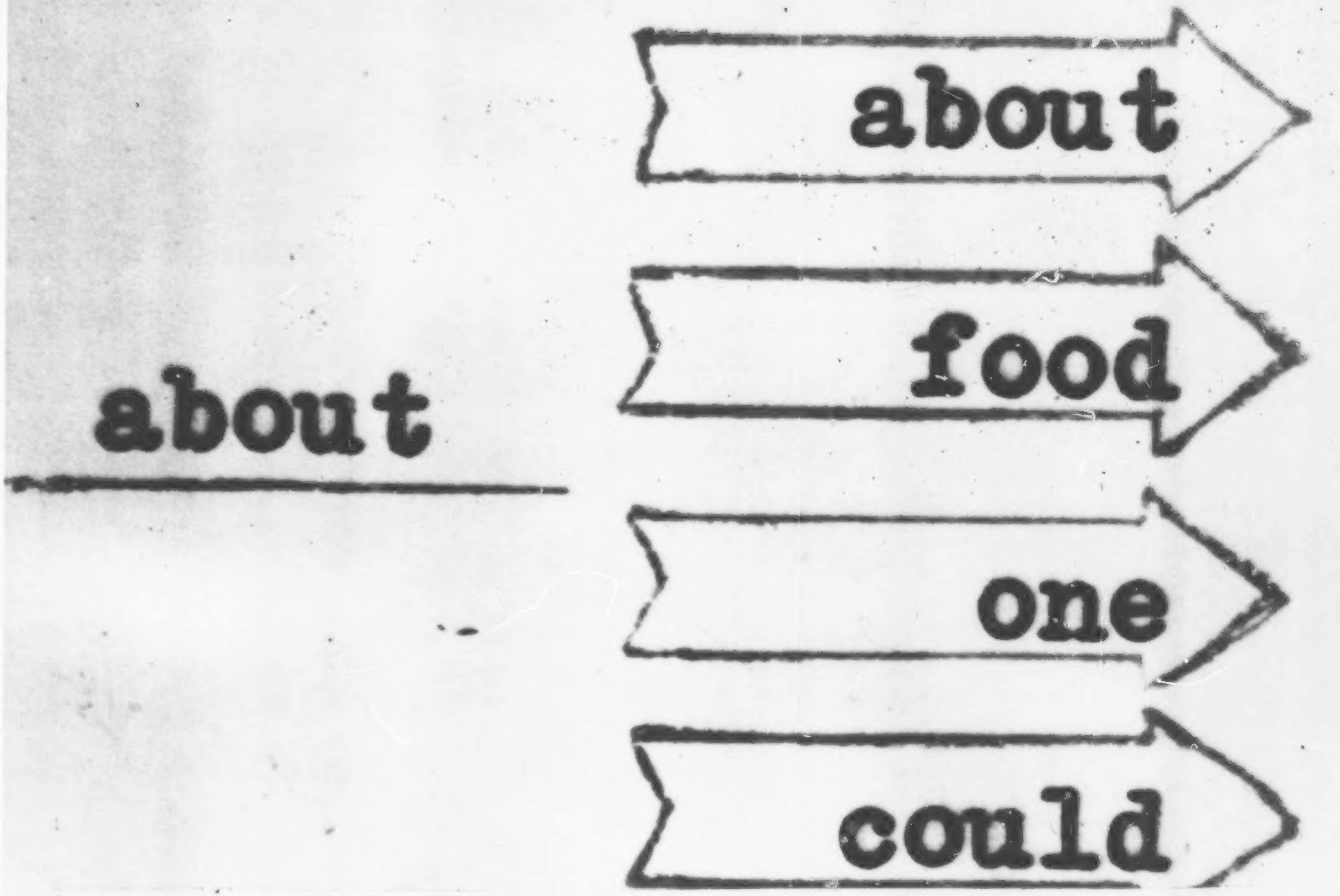

about
about
food
one
could

Fig. 18.2. A reproduction of the visual portion of a maximal support frame.

Achievement Tests (Hildreth, 1947), the Wide Range Achievement Tests (Jastak & Bijou, 1946) and a test devised by the authors. The IQ range for all Ss was from 46 to 66 with a mean of 52.57. The range of Metropolitan scores was from 1.1 to 1.4 with a mean of 1.24. On the Wide Range test, the range of scores was from .5 to 2.5 with a mean of 1.76.

Design

One of the three groups served as a control, receiving feedback from a red light for incorrect responses and a green light for correct responses. In addition to the lights, a correction technique was used, i.e., the next frame appeared only after S made the correct response. The second group received the same treatment as the first; however, in addition, the second group also received, as 100% tangible reinforcement, one piece of M & M candy for every correct response. The conditions of treatment for the third group were identical to those for the second except that S received only 25% variable or random tangible reinforcement for correct responses.

Several types of learning measures were collected. (1) The last eight frames of the program were test frames, i.e., non-support frames as previously described. (2) At the conclusion of the program, S was immediately shown four flash cards (one at a time) each bearing one of the words taught by the program. E asked S what each word was (recall) and recorded the response. (3) This flash card recall test was repeated 24 hrs. after training.

The same program was used to train all Ss. Since it had been determined by pre-test that no S knew any of the words to be taught, and since the groups were equated on the variables of achievement level, IQ, and age, any group differences should be attributable to the type of reinforcement.

Results

On the last eight frames (test frames) of the program, the mean number of correct responses for the control group was 5.6. For the 100% tangible reinforcement group, the mean number of correct responses was 4.7. For the final (25% variable) group the mean was 5.4. Since t-tests indicate that none of these differences is statistically significant, the hypothesis that there is a difference among the three conditions cannot be accepted.

The group means for the recall test immediately following training were: Control - 1.7; 100% - 1.6; 25% - 2.0. These do not differ significantly from each other. Difference scores were obtained for Control Ss and those in the 25% groups by subtracting the 24 hr. retention score from the post training scores. A Mann Whitney-U test (Tate & Clelland,

Table 18.1

Mean Correct Responses for the Three Groups on Three Criterion Measures

and Means Converted to Percentages Correct

Group	Test Frames Last 8 Frames*		Post Training Test Flash Cards**		24 hrs. Retention Flash Cards**	
	(Recognition)		(Reconstruction)		(Reconstruction)	
Control	5.6	70%	1.7	43%	1.0	25%
100% Tangible Reinforcement	4.7	59%	1.6	40%	1.0	25%
25% Variable Tangible Reinforcement	5.4	67%	2.0	50%	1.7	43%

* Presentations of each of the four words, randomly.

** Presentation of each of the four words, randomly.

1957) was then computed to compare the difference scores of the two groups; no significant difference was found.

An exact X^2 test for small samples (Tate & Clelland, 1957) was run on 24 hr. retention test data. This test compared the Control and 25% Variable Groups on number of cases falling above the median with number of cases falling at or below the median. This test ($X^2 = 3.25$ with df = 1) also failed to reach significance of the .05 level.

Table 18.1 is a summary of all the group means, and the means converted to percentages. It will be noted that the figures in the first column of Table 18.1 are considerably larger than those in column 2 and 3. There are two reasons for this. First the mean scores in the first column are based upon two presentations of each word while those in the second and third column are based on a single presentation of each word. Secondly, the test frames constitute a recognition task while the two flash card tests are reconstruction tasks which require transfer of training and are more difficult than simple recognition.

Discussion

The original hypotheses were that, 1) tangible reinforcement in addition to K/R would produce a learning increment; and 2) variable reinforcement would more greatly facilitate learning than would 100% reinforcement. The results of this study, in agreement with the findings of Eigen (unpublished) and of Moore and Smith (1963), do not give statistical support to the hypotheses. However, there is a trend in the direction predicted by the second hypothesis. The 25% group learned more and lost less. No such trend had been reported by Moore and Smith (1963). One of the conclusions of the Moore and Smith study was that, "Neither intrinsic nor extrinsic rewards in programmed instruction contributed significantly to student achievement ...". This very probably would not be true with the type of material used in this study. The material used by Moore and Smith was the Holland-Skinner psychology program (1961) in which the information to be learned can be ordered and presented in logical sequence. The types of material taught in beginning reading, however, make it a rote learning task which requires some sort of reinforcement.

There appear to be two possibilities which would explain the results. First, it may be that M & M candy is, under the circumstances, no more rewarding than K/R. If food intake could have been controlled in order to manipulate drive level, a better test of the hypothesis might have resulted. On the other hand, it might be that K/R is sufficient to produce maximum learning from this program. That is, perhaps S can learn no more from this program regardless of whether or not reward is increased. If this is so, then the program, not the reward, must be modified to increase learning. One of the major difficulties inherent in this investigation (and others dealing with non-readers) is the establishment of a basal level of functioning; i.e., how much of a non-reader is an individual who does not recognize selected words? Matching on reading achievement is standard practice for such experiments, but it does not account for the degree of functioning below a zero score, Hence, Ss matched on the basis of non-achievement may, in reality, be functioning at various stages of readiness. This variable, although uncontrollable in a practical sense, must be taken into consideration when examining the results of such investigations.

Summary

Three groups of ten mentally retarded adolescent males with little or no reading ability were presented, by a teaching machine, with four words which they previously did not know. The first group (Control) received only knowledge of results as reinforcement. In addition to knowledge of results, the second group received 100% tangible reinforcement (one piece of M & M candy for each correct response). Group three received knowledge of results and 25% variable tangible reinforcement (M & M's). There were no significant differences found between groups on any of the three learning and retention tasks.

It was concluded that with the program used, neither of the two levels of tangible reinforcement in addition to knowledge of results produced a significant learning increment when compared to knowledge of results alone.

References

Blackman, L. S. & Holden, E. A. Support vs. non-support in an auto-instructional word program for educable retardates. Amer. J. ment. Defic., 1963, 67, 592-600.

Eigen, L. D. Center for Programmed Inst., New York, unpublished report.

Hildreth, Gertrude H., Metropolitan achievement tests, Yonkers-on-Hudson, New York & Chicago, Ill: World Book Co., 1947.

Jastak, J. & Bijou, S., Wide range achievement test, Wilmington, Del: G-1 Story Co., 1946.

Moore, J. W. & Smith, W. I. The role of knowledge of results in programmed instruction, Bucknell Univer., 1963, Mimeograph.

Spradlin, J. Effects of reinforcement schedules on extinction in severely mentally retarded children. Amer. J. ment. Defic., 1962, 66, 634-640.

Stevenson, H. & Zigler, E. Probability learning in children. *J. exp. Psychol.* 1958, *56*, 185-192.

Tate, M. W. & Clellan, R. C. *Non-parametric and shortcut statistics.* Danville, Ill: Interstate Printers & Publishers, Inc., 1957.

Thorndike, E. L. & Lorge, I. *The Teachers Word Book of 30,000* Words. New York: Bureau of Publications, Teachers College, Columbia Univer., 1944.

Wechsler, D. *The Wechsler intelligence scale for children.* New York: Psychol. Corp., 1949.

Chapter 19

A Glossary of Terms Used in Auto-Instructional Methods

Marshall P. Smith

abstraction: "a response to a single property of a complex stimulus. Example: response "carnivore" to picture of a German Shepard" (AID, 1962)

access time: "amount of time elapsed in getting to an item in a program. This time is used in computer terminology as the amount of time it takes the machine to search for a particular bit of information and produce it." (AID, 1962)

action feedback: a continuous flow of information advising a learner of his performance of an on-going task. Compare learning feedback.*

active response: an overt response by the learner to an item. See multiple-choice response: constructed response. Contrast passive response.

adaptive machine: see teaching machine (basic types) (Stolurow, 1959).**

adaptivity: "the capacity of the teaching machine and its associated program to adjust, in one or more ways on the basis of the learner's responses, to his specific needs." (AID, 1962).

alternative programming: syn.with intrinsic programming.

alternating trial-test: a sequence of items in which an item using prompts to establish a bond is immediately followed by an item testing that bond without prompts.

anticipation: the introduction of a bond as an irrelevancy in several items preceding the training trial for that particular bond (Porter, 1959).

artificial feedback: information furnished the learner concerning his performance by means of signals (e.g., clicks, lights) not intrinsic to the learning task. Compare operational feedback.

---

* Underlined terms are included in the glossary.

** References are to sources listed in the bibliography.

asynchrony: " a method of presenting items in which (a) a changing stimulus requires the same responses or (b) a fixed stimulus requires changing responses." (AID, October, 1962).

atomic item: apparently refers to an *item* conveying a discriminable amount of additional knowledge (Galanter, 1959). See *unit response*; bond.

atomic items; exhaustive set of: "An exhaustive set of atomic *items* for. . . an arithmetic program contains an example of every problem in arithmetic. This set clearly is infinite." (Galanter, 1959).

augmenting item: (1) an *item* supplying new information to the learner. See item (types) (Schutz, 1959). See *panel, defin. 1.* (2) an item in which the stimulus of the initial S-R connection is paired with the stimulus of the first transitional S-R connection, the response being that of the initial S-R connection (Gilbert, 1958).

auto-comparator: "a device which automatically compares *S*'s response with a standard or criterion depending on *S*'s judgment. At present such auto-comparison is commercially available only for discrete selective responses except in a keyboard machine like the TMI Wyckoff device." (Shettel, Lumsdaine, 1961a).

auto-instructional method; automation of teaching; automated teaching: teaching by an instructor-saving contrivance "whereby. . . sequences of instruction. . . are completely prepared in advance of use, and. . . are capable of instructing effectively when presented with minimal direct participation by a teacher" (Lumsdaine, 1959a; Lumsdaine and Klaus, 1960).

automatic tutoring: "the term for 'programmed instruction' most frequently used with *intrinsic programming*."

Autotutor Mark II: "a brand name for a teaching machine produced and sold by U. S. Industries, Inc." (AID, 1962).

availability: see *programming (principles)* (Carr, 1959b).

backward branching: the review of material already completed, syn. with *recycling*.

binary frame selection: "the simplest form of branching. There are at most only two alternative routes at any point in the program." (AID, 1962).

blind control group: a group of subjects selected at random without their knowledge for comparison purposes (Gustafson, 1960).

blind questions: multiple choice questions with no prior instruction and no feedback in the responses. (Gustafson, 1960).

bond: (1) any connection between a stimulus and a response, hence a unit of information in a program. (2) the hypothesized change in the organism as a result of the establishment of a connection between a stimulus and a response (Griffith, 1960).

book: syn.with set (Keislar, 1960).

branching: the process whereby the device, in response the learner's decision, governs the sequences of the program through: (a) control of the size of step by permitting skipping when criteria of accomplishment are met; (b) recovery of lost material by return to earlier items or remedial items. See washback. Branching accommodates the program to individual differences. Compare straightline programming.

branching, frame level: "the typical by-pass of a certain limited number of frames based on the correctness of a response to a particular frame." (Shettel, 1961).

branching, optional: the learner, at his own discretion, is permitted to review or skip (Soulson and Silberman, 1961).

branching, segment level: "the omission of certain portions or segments of the program for those who demonstrate that they are already proficient in that particular area." (Shettel, 1961).

Card-Sort Device: a multiple-choice device where the stimulus and from two to four response choices appear on cards. The device has a selective function. (Briggs, 1959).

cartesian method: "an approach to handling complex problems which may be useful in programming subject matter. It involves essentially two activities: (a) analyzing the problem into its smallest parts, and (b) proceeding from the simple to the complex." (AID, 1962).

chaining: a process whereby a pattern of behavior is established by making each response become the stimulus eliciting the next response. See conversational programming; error chaining.

cheating: the learner's discovering of the correct answer before he makes his own response.

Chemo-card: a device for self-scoring of multiple-choice responses by litmus paper spots on the score sheet. Right and wrong choice points register differently when marked with a wet stylus. (Peterson, 1930).

choices: "refers to the selection of an answer from several alternatives presented to the subject as opposed to having the subject construct or write out an answer." (AID, 1962).

class-descriptive program: a program in which similar components of various objects are assembled for presentation as a class of features (Stolurow and Hasterok, 1960). Compare object-component program.

coaching mode: syn. with quiz mode. See confirming modes.

collator function: see teaching machine (functions) (Stolurow, 1959).

collator-recorder: "the component of a teaching machine which records number of errors, type of error, response latency etc. by frame number."

comparison answer: the correct response which is exposed to the learner after his response in a constructed response program.

composed response: syn. with constructed response.

confirmation technique: where the correct response is given the learner only after his response. Compare response prompting.

confirming mechanism: a teaching machine component which informs the learner of the correctness of his response. See teaching machine (components) (Carr, 1959b).

confirming mode: an arrangement of feedback in relation to the learner's response, especially with multiple-choice devices (Irion and Briggs, 1957; Briggs, 1958): (a) coaching mode: syn. with quiz mode. (b) modified-quiz mode: the learner, if correct, proceeds; if wrong, he is immediately given the correct response, syn. with single-error permitted mode. (c) practice mode: the learner responds until the correct response is made. (d) single-error-permitted mode: syn. with modified-quiz mode. (e) single-try mode: the learner is allowed one response only, with feedback. (f) test mode: the learner is allowed one response only, with no feedback. (g) quiz mode: the learner is given the correct response immediately after presentation of the problem, syn. with coaching mode; response prompting.

constructed-recognition response: a response mode in which the learner responds to an item by inspecting two or more furnished choices and writing out the one he thinks is correct. Compare: constructed response; multiple-choice response.

constructed response: a written or otherwise created answer made by the learner for comparison with the criterion. Syn. with composed response. See write-in device. Compare multiple-choice response.

constructed response element: that part of a total response that the learner must supply, e.g. omitted letters in a spelling word.

constructed response program: the learner must make to each item a written or otherwise creative response which only then may be compared to the criterion. Compare multiple-choice program.

context: "that part of a frame which helps to provide understanding of a fact by showing how that fact is related to other things or facts." (Shettel, Angell, Lumsdaine, 1961).

continous vanishing: a prompting technique wherein a stimulus support, such as degree of illumination, is continuously decreased until the stimulus stands alone. See prompt; vanishing, defin. 1.

contrast: a technique of introducing a concept by showing what it is not. A type of prompt.

conversational programming (chaining): the ordering of material so that the comparison answer selected by the programmer serves to some extent as both a reinforcing stimulus and as a discriminative stimulus for the next item, thus developing chaining. (Barlow, c. 1960).

copying frame: "a type of frame which uses the "copying" programming technique to elicit the correct response under appropriate conditions. The pupil merely duplicates the response portion of the frame, which is given in full." (AID, 1962).

correction technique: a method of handling the learner's response wherein if he is correct the experimenter gives feedback; if he is incorrect the experimenter gives feedback, tells the correct response, requires the affirmation of the correct response by the learner, and then gives feedback (adapted from animal learning.) Syn. with modified-quiz mode, single-error permitted mode.

covert response: the subject meeting a question, thinks of the answer prior to receiving feedback. Syn. passive response. Compare overt response. Contrast response prompting.

criterion: the measure of a learner's achievement of a given task.

Crowder-Pressey type program: syn. with Pressey-Crowder type program. cue: (1) syn. with prompt. (2) a direct form of prompt in which, for example, the response term may be given before the response by the learner.

cue reduction: syn. with vanishing, defin. 1.

cueing: syn. with prompting.

cumulative density: "the density of any portion of a program in its relation to materials which have been presented in preceding lessons." (AID, 1962).

cutback-page booklet: "a booklet designed with each succeeding page narrower than the preceding one. An answer sheet is placed under the smallest page so that its right edge extends beyond the rest of the test, providing blanks for responding to frames in the text. The correct answers are printed on the answer sheet in a position such that the frames to which the answers belong are on a page above the answer sheet which must be turned to expose the answers." (AID, 1962).

cycle: a single run-through of a set of items. See recycling.

data frame: syn. with panel def. 2. See frame def. 2.

deductive program: a concept is given, followed by various elaborating instances. See Rules. Compare inductive program.

delayed review: the introduction of review items after the development of other materials (Schutz, 1959). Compare rote review: restated review.

density: "the rate at which new material is introduced. It is the ratio of the number of different responses required of the learner to the total number of responses required. Independent for a single set of frames and cumulative for a sequence of sets. All different responses have a density of 1.00" (AID, 1962)

developmental sequence: a series of items graded in difficulty, familiarity, or abstractness in order to teach a particular concept.

differential programming: "in differential programming, variation in the program is a function of pupil characteristics." (AID, 1962)

discrete item program: a program teaching bonds which are relatively unrelated, e.g. vocabulary words; tool nomenclature. Compare chaining.

discriminator operator: see operator.

discursive program: materials to be learned in sequence, each item depending on the mastery of preceding items. See chaining. Compare paired-associates learning.

disk: (disc): syn. with set.

display: (1) a component of a teaching machine which presents a stimulus to the learner. See teaching machine (components) (Carr, 1959b). (2) Syn. with panel, defin. 1.

distance (item): the discreteness of adjacent items in a program. In chaining, syn. with step-size.

distractors: syn. with foils.

double inside alternatives: a response choice pattern in which the foil for item (a) is the correct response for an adjacent item, (b) the foil for which is the correct response for item (a). See inside alternative.

dovetailing item: an item which brings together in one problem separate already effective stimuli which might otherwise become confused. See item (types) (Schutz, 1959).

drop out: the omission of correctly answered items from a set before it is recycled. A type of branching.

Drum Tutor: a four-choice multiple-choice device showing cumulative error count (Stephens, 1953).

Ebacher grill: a piece of transparent plastic with opaque strips across it so that, when placed over a page of material, it masks out every other line (Barlow, 1961).

egrul: "see ruleg" (Markle, undated).

elicitor: that part of a stimulus which leads the learner to the making of a response.

error chaining: the linking, by the learner, of an incorrect response to a response.

error probability: (1) the likelihood that a certain item will be answered incorrectly. (2) the percentage of errors in responses to a set or program (Galanter, 1959).

error rate: "refers to the number of percentage of a given group of subjects incorrectly responding to a specific item on the program. A high degree of error would probably indicate a need for revision in the program." (AID, 1962).

error ratio: correct responses divided by error responses (Gustafson, 1960). see error probability defin. 2.

exercising: the presentation of several items, each involving utilization of the same bond (Skinner, 1959).

exhibit: information additional to that in the program proper presented to the learner.

extrinsic programming: syn. with straight-line programming. Compare intrinsic programming.

fading: syn. with vanishing, defin. 1. See item (types) (Schutz, 1959).

feedback: information concerning the correctness of a response to an item, conveyed to the learner by the teaching machine by some type of signal. See teaching machine, (functions) (Stolurow, 1959).

force frame: a unit of instructional material depends on an obvious and explicit prompt to elicit the appropriate response rather than on data in the item (Eigen, 1960). See frame def. 2.

forcing: "the presentation of subject matter in such small steps as to assure a correct response by the learner." (AID, 1962).

formal prompt: a technique for eliciting a response by giving cues based on the structure of the response, e.g. rhymes, echoic words, initial letters (Skinner, 1958). See prompt. Contrast thematic prompt.

forward branching: syn, with skipping. See branching.

four-pair item: a multiple-choice item offering the learner, as response choices, three correct pairs and one incorrect pair. The learner's task is to find the incorrect pair (Sevrin, 1955). See two-pair item.

frame: (1) syn. with item, defn. (2) a unit of auto-instructional material composed of (a) an operational component requiring an action on the part of the learner; (b) a data component giving information for use by the learner (see panel, def. 1); (3) an instruction component telling the learner what to do at the completion of the operation. (Eigen, 1960).

functional prototype (or, simply "prototype"): "For purposes of this glossary, an experimental apparatus which exemplifies the functional characteristics desired of a self-instructional device or system (or principal component thereof), but which does not necessarily (as distinguished from a "production prototype") embody the specific physical dimensions or construction details that would be adopted for later production." (Shettel and Lumsdaine, 1961a).

generalizing item: an item which summarizes the common characteristics of several items already presented to the learner. See item (types) (Schutz, 1959).

group-pacing: the presentation of items in a program at a rate adjusted to a group rather than to an individual. Compare self-pacing; machine pacing.

hardware: mechanical or electronic device of any sort.

Hawthorne effect: the spuriously high motivation and/or performance often shown by a subject who knows he is part of a psychological experiment.

hint: "devices used to direct the student's behavior in the desired direction. Used to increase the likelihood of a correct response." (AID, 1962).

immediate reinforcer: a stimulus-response device which presents material and provides feedback concerning the response (Porter, 1958). Compare simulator, pacer.

implicit response: the learner reads the underlined correct response (Goldbeck, 1960). Compare active response, passive response, response prompting, syn. with reading response. See text-book program.

inductive program: items are organized so that the student comes to learn a concept as it is developed. Compare deductive program, Ruleg.

initial S-R connections: bonds already possessed by the learner which, to some degree, approximate the bonds the programmer wants to teach (Carr, 1959b).

inside alternative: a response choice in a multiple-choice item which, if incorrect, appears as a right choice for another item in the same set (Stephens, 1953). See double inside alternatives. Compare outside alternative.

instruction frame: an item containing only directions for the learner. See frame def. 2.

intrinsic programming: a technique which allows branching at any item (Crowder, 1959). Compare straight-line programming. See scrambled book.

intrusion: an incorrect response during a test trial in paired associates learning. It may or may not be a correct response to another item.

item: (1) a single stimulus situation which is presented to the learner and which calls for a response. Syn. with frame, def. 1. (2) syn. with frame, def. 2.

item (types) (Schutz, 1959): (a) lead-in; leading: introduce the learner to an area and prepare him for new information. (b) augmenting: supply new information but do not require response. See panel, defin. 1. (c) vanishing; fading: reduce stimulus cues until the stimulus stands alone. (d) specifying: exemplify a general rule through specific examples. (e) generalizing: summarize the common characteristics of specifying items already presented. (f) dovetailing: bring together concepts which might otherwise be confused.

items; additional types: "(a) interlocking: an item requires a student to review the established skills while new information is being presented. (b) restated review: an item requiring a rehearsal of the skill where a problem is restated. (c) tab: a specialized term referring to having the subject pull a tab to indicate his response rather than writing out an answer or selecting a choice." (AID, 1962).

knowledge of results: "a report to a student on the status of the response he made. It may take the form of a verbal report "Right" or "Wrong" (or lights, buzzers, etc., signaling these), or a display (oral or written) of the correct verbal response. It may be a response of a manipulandum; some teaching machines advance to the next item only when the correct response has been given."

lead-in item; leading item: See item (types) (Schutz, 1959).

learner-pacing: syn. with self-pacing.

learning feedback: discrete feedback to a specific response. Compare action feedback.

level: one of the several series of items, each item of which appears in a corresponding position on a page of a programmed textbook. See panel, defin. 2.

library unit: "a component in a teaching machine used to store the program. The selector unit picks items to be presented from the library unit." (AID, 1962).

linear program: "a program which has a single, predetermined sequence of steps. Error responses are not correct or immediately repeated. A drop out device can be incorporated into the machine whereby errors may be reviewed at the end of the set sequence." (AID, 1962).

machine-pacing: a procedure where the machine determines the rate of presentation of material either within or between items. Compare self-pacing, group-pacing.

maintenance: See programming (principles) (Carr, 1959b).

manipulandum: that part of the teaching machine manipulated by the learner.

many-to-one program: an order of presentation wherein a concept is developed by presenting many examples leading toward a single generalization (Stolurow and Hasterok, 1960). Compare one-to-many program.

matching: "procedure used in some Skinner machines to inform student of correctness of his response. After writing his response, the student moves a lever which exposes the correct answer with which the student compares or "matches" his response." (AID, 1962).

mathetics: "an approach to programming designed by T. F. Gilbert. [illegible] guidelines for [illegible]

[illegible] each bond is made as different as possible from those near it in the program, e.g. in spelling--dog, see, chair (Stolurow and Hasterok, 1960). Compare minimum-change program.

minimum-change program: an order of presentation wherein each bond is made as similar as possible to those near it in the program, e.g. in spelling--car, cat, cap (Stolurow and Hasterok, 1960). Compare maximum-change program.

misleads: syn. with foils.

mixed sequence: a series of items where each item presents a new [illegible] and Newland, 1956). Compare unmixed sequence.

modified-quiz mode: a procedure where a learner is permitted only one answer per item. See confirming mode.

multiple-choice device: a machine designed to handle multiple-choice items.

multiple-choice item: an item to which the learner responds by selecting the correct answer from among a limited number of specific alternatives. Compare multiple-response item.

multiple-choice program: a program where the machine offers the learner certain specific response possibilities. Compare constructed response program.

multiple-choice response: the learner's reaction to a multiple-choice item.

multiple-response item: an item to which the learner responds by selecting the one or more correct response choices from among a limited number (Willey, c1959). Compare multiple-choice item; foil.

negative feedback: the indication to the learner that his response is incorrect.

non-adaptive machine: see teaching machine (basic types) (Stolurow, 1959).

novelty effect: temporary improvements of a learner's performance owing to reinforcement deprived from new experiences.

object-component program: an order of presentation where an object is presented and its various components are pointed out (Stolurow and [illegible]). Compare class-descriptive program.

objective: [illegible] goal toward which instruction is [illegible] to reach this goal by the end of [illegible], 1962)

one-to-many program: an order of presentation where a concept is developed by presenting a generalization followed by many examples (Stolurow and Hasterok, 1960). Compare many-to-one program.

operational feedback: information furnished the learner concerning his performance by signals which are intrinsic to the task (Miller, 1954). Compare artificial feedback.

operator: the label of an RU Matrix which names the particular interrelationship involved, classified for example, as relator operators describing RU (rule) similarities, discriminator operators describing RU differences (Rigney and Fry, 1961).

option response: the learner may choose to make or not to make an overt response (Goldbeck et al., 1960).

output characteristic: (1) a dimension of the learner's response, e.g. multiple-choice response; constructed response. (2) the machine's capacity for handling the learner's response.

outside alternative: a foil in a multiple-choice program which is selected from materials irrelevent to the program. Compare inside alternative.

overt response: the subject meeting a question, shows his answers by some observable behavior. Synonymous to active response. Compare covert response.

overprompting: "undesirable feature of some programs in which a text of frames has an excessive number of prompts. The student is likely to become overly "dependent" on program-supplied responses, making weaning more difficult." (AID, 1962)

paced-practice: syn. with machine-pacing.

pacer: a stimulus-response device which presents material and moves on regardless of response (Porter, 1958). Compare simulator; immediate reinforcer.

pacing: the rate of presentation of material either within an item or from item to item. See self-pacing; machine-pacing; group-pacing.

pacing, controlled rate: "control of the subject's rate of responding by features of the mechanical device utilized to present the program." (AID, 1962).

pacing, function: See teaching machine (functions) (Stolurow, 1959).

paired associated learning: a task in which a single stimulus must be matched with one or more response choices, each item being relatively discrete, e.g. foreign language vocabulary. Compare chaining.

pall effect: loss of motivation by a learner as a result of working through too many items perceived as lacking in challenge (Rigney and Fry, 1961). See novelty effect, Hawthorne effect.

panel: (1) a chart or paragraph or other material which serves as a reference for certain items in a program (Holland, 1959b) (2) in a programmed textbook one of several areas on one page where discrete items are displayed. See level. (3) See response panel.

partially adaptive machine: See teaching machine (basic types) (Stolurow, 1959).

passive response: a learner's covert reaction to the stimulus.

pinball effect: an advantage in achievement, probably temporary, accruing to users of a teaching machine as a result of its novel manipulative characteristics.

placebo effect: synonomous with Hawthorne effect. See novelty effect.

Porter-type device: "a write-in machine of the type described by Porter (1958) in which the student writes directly on the program materials (which therefore are not re-usable.) An example is the commercially available TMI-Grolier "Min-Max" machine" (Shettel and Lumsdaine, 1961a)

position effect: the possible biasing of multiple-choice items as a particular position in the response display, e.g. choice of the first alternative. See response set.

positive feedback: the indication to the learner that his response is correct.

practice mode: a procedure where the learner continues to react until he makes the correct response. See confirming mode.

presentation function: See teaching machine (functions) (Stolurow, 1959).

Pressey-Crowder type program: usually a branching program using multiple-choice responses. Syn with Crowder-Pressey type program.

preverbal machine: "a machine which presents frames in the form of pictures or figures which may be matched or contrasted; no words are used in the frames presented. Such programs can be used with pupils of pre-reading age." (AID, 1962)

problem: syn. with item.

procedural trainer: a machine for teaching complex procedural aspects of equipment maintenance (Briggs, 1959b).

program: an ordered body of material through which the student works.

program error sources: (a) failure to delineate subject matter. (b) over-or under-estimation of learner's original knowledge. (c) failure to supply sufficient exercise of a bond. (d) failure in the order of materials, e. g., complex before simple. (e) program may be too rapid in raising level of complexity.

programmed textbook: a teaching machine in the shape of a book where the first item appears at the top of the first page, first criterion and second item at the top of the second page, second criterion and third item at the top of the third and so on to the end of the book; thence back to the first page with the next item presented immediately under the first (Homme and Glaser, 1959). See level; panel, defin. 2.

programmer: the individual who determines the nature and sequence of the material going to make up a program.

programming: the process of developing a program for a teaching machine.

programming function: See teaching machine (functions) (Stolurow, 1959).

programming (principles) (Carr, 1959b): (a) relevance: problems should be like those the learner is eventually to solve; the responses should approximate the ultimately desired responses. (b) availability: the initial S-R connections must be specified. (c) sequence: the optimum order of presentation must be indicated. (d) stepping: step-size must be determined. (e) maintenance: amount of conditioning necessary to guarantee adequate learning must be specified. See revision.

progressive branching: Sending the student, after the correction of an error, on to a new item--rather than to the original item missed (Gustafson, 1960).

prompt: (1) a cue or hint to facilitate a desired response which might not otherwise be made. (2) to offer such cues or hints. See formal prompt; thematic prompt; prompting (types of).

prompting (types of) (Smith, 1959) (Schutz, 1959) (AID, 1962): (a) similarity: of ideas, grammatical construction, rhymes. (b) contrast: of ideas, of signals. (c) grammatical construction: limiting range of response. (d) echoic devices: using perseveration to elicit response. (e) whole to part; using the whole to elicit appropriate step responses. (f) hints: referring to earlier learnings. (g) mechanical devices: as color, underlining, capitals. (h) emphasis: usually an underlined word or phrase written in capital letters to give it emphasis.

pull-tab device: a self-scoring device where the response is made by pulling a tab from the answer sheet thereby exposing an indication of right or wrong and, in some types, short verbal explanations for each alternative (Bryan and Rigney, 1956).

punch-board device: a multiple-choice device with feedback and a record of correctness of responses (Pressey, 1950).

pure-part method: "a method of sequencing programmed instruction in which each part is first learned separately to a criterion of mastery. Subsequently the parts are repeated until the whole has been brought to the criterion already achieved by each part." (AID, 1962)

quickening procedure: "giving the student knowledge of the results of his response while he is still in the process of making the response. Example: after writing the first one or two letters of a response word, the student would be told he is incorrect." (AID, 1962)

quintain: "known as a medieval teaching machine used to train knights. The appropriate response was to strike a shield directly in the center with a lance. If it struck off center, the device would deliver feedback by striking the horseman a blow as he rode by." (AID, 1962)

quiz mode: a procedure where the learner is informed of the correct response immediately after presentation of the item. See confirming mode.

reading response: syn. with implicit response (Goldbeck et al., 1960). See text-book program.

recall mode: the constructed response method of programming.

recognition response: syn. with multiple-choice response.

recycling: (1) the learner's re-working of a set after its completion. (2) the mechanical return of a set to its starting position.

redundancy: the condition which occurs when material is presented more than once in the same or different contexts.

reinforcers, primary: "a class of stimuli which will, without any prior history of training, reinforce operant behavior." (AID, 1962)

reinforcement: the experience in which a learner discovers through feedback or reward, or both, that his response is correct for the problem presented. Further behavior is elicited.

reinforcement mechanism: a machine component which provides impetus for further operation of the device. See teaching machine (components) (Carr, 1959b).

reinforcement schedule: the frequency and order in which reinforcement is given, e.g. for every correct response (100% reinforcement), only for some responses (partial reinforcement).

relational guidance: "a technique used when a principle is to be applied in a variety of contexts, each requiring a different objective response." (AID, 1962)

relator operator: see operator.

relevance: see programming (principles) (Carr, 1959b).

response choice: any one of the possible answers presented the learner in a multiple-choice item.

response, constructed: "a response produced by a student to complete a sentence, solve a problem, or answer a question. A model of the response may be provided for the student to copy, but as long as he writes, says, or thinks it rather than selecting it from a set of alternatives, the response is constructed." (Markle, undated)

response, covert: "an internal response which the student presumably makes, but which is neither recorded nor otherwise available to an observer. A student who is producing an oral or written response usually thinks of the response (i.e., responds covertly) before he responds overtly. On this basis several experimenters have hypothesized that covert responding should result in learning and have found no measurable differences between overt and covert responding under the conditions of the experiments. (Markle, undated.)

response device: a machine which provides the learner with an opportunity to practice some activity, e.g., a typewriter (Porter, 1958). See teaching aid; stimulus device; stimulus-response device.

response distinctiveness: the discreteness of response choices (Griffith, 1960).

response fractionation: the extent to which the response is divided into small time segments (Griffith, 1960).

response guidance: syn. with prompting.

response, matched: "after writing his answer, trainee discloses several possible answers, and he then indicates which one his answer matches." (Shettel and Lumsdaine, 1961b)

response, overt: "an oral, written, or manipulative act on the student's part which is, or can be, recorded by an observer. While research has failed to demonstrate a significant increase in acquisition as a result of saying or writing responses rather than 'thinking' them, overt responses provide the data on the basis of which programs are revised." (Markle, undated)

response panel: a machine component which accommodates the learner's reaction to the problem. See teaching machine (components) (Carr, 1959b).

response-prompting: a procedure in which the correct response is exposed after the stimulus and before the learner makes his response to the stimulus. Compare confirmation technique.

response range: the number of responses to the problem available to the learner (Griffith, 1960).

response, self-corrected: "after writing his answer, trainee then discloses the correct answer for comparison and judges whether his answer was right or wrong." (syn. Matching) (Shettel, and Lumsdaine, 1961b)

response strength: "how well the response is learned. Depends partly on the number of times the response is called for in the program and how effectively it is cued. The greater the response strength the more likely it will be remembered. Terminal recognition behavior requires less response strength than terminal recall behavior." (Shettel, Angell, and Lumsdaine, 1961)

rote review: the identical repetition of an item presented earlier (Schutz, 1959). See restated review: delayed review.

ruleg: "a system in programming which consists of a statement--such as a rule, principle, or definition--followed by one or more examples may occur in the same frame; or in a series of frames." (AID, 1962)

Ruleg System: a method of programming where a rule is propounded and followed by a series of examples. Also called Rule-Example system (Evans, Glaser, and Homme 1960). Compare inductive program; see deductive program.

RU Matrix: in the Ruleg System, a typical arrangement of rows and columns such that each RU (rule) is related to every other (Rigney and Fry, 1961). See operator.

S: the learner, student, subject.

scanning principle: a technique of teaching machine design in which a window passes across the text in contrast to more common techniques in which the material is moved behind a window (Barlow, 1961).

schedule of reinforcement: see reinforcement schedule

scrambled book: automated instruction in the form of a book which permits the programmer to anticipate error responses and to build in the maximally adaptive branching function, usually with multiple-choice items.

scrambled book:
Each response choice, in addition to giving feedback, leads the learner either ahead if he is correct or to remedial work if he is incorrect. This is intrinsic programming (Crowder, 1959).

scrambling: in the Subject-Matter Trainer, an automatic technique for changing the order of correct responses.

seeding: the introduction of review material into later items (Skinner, 1959).

segment: "a unit of frames identified as covering a particular skill or related group of skills. It is smaller than a program but bigger than a sequence. Generally leads to some important part of criterion or terminal behavior." (Shettel, Angell, and Lumsdaine, 1961)

selective function: See teaching machine (functions) (Stolurow, 1959).

self-pacing: a procedure wherein the learner controls the rate of work by determining the time he will take before making a response, and, in some programs, the time lapse after feedback and before the appearance of the next item.

self-scoring test: an exercise wherein the student gets immediate knowledge of his performance.

sequence: See programming (principles) (Carr, 1959b).

sequential instruction: material presented in a set of items designed to teach a predetermined order of behavior, e.g. in maintenance work. See chaining. Compare paired-associates learning.

series: syn. with set.

set: a group items intended by the programmer to be performed at one sitting.

shaping: bringing the learner to emit a desired low probability response by differentially reinforcing high probability components of that response.

simulator: a stimulus-response device which duplicates a complex task often without feedback (Porter, 1958). Compare immediate reinforcer; pacer.

single - branching: recycling a set when the learner makes an error on a quiz.

single-error-permitted mode: syn. with modified-quiz mode. See confirming mode.

single-try mode: a procedure wherein the learner is permitted only one response to each stimulus. Feedback is given. See confirming mode.

Skinner disc: "a round, flat, record-like device which contains a set or series of program materials for the Skinner device. Contains the questions to be answered, spaces for recording student's answers and the correct response, as well as for making a record of successful performance." (AID, 1962)

Skinner-type device: "a write-in machine combining a WID element separate from the program-frame presentation element so that the student does not write directly on the program materials (which can therefore be re-used). Examples are Skinner's disc machine and the commercially available Rheem Didak Model 501 and the Koncept-O-Graph." (Shettel and Lumsdaine, 1961a)

Skinner type machine: a write-in device for a constructed response program.

Skinner type program: usually a straight-line program with constructed responses where each item depends upon preceding items.

skipping: the passing over of certain material by a learner who has met a specified criterion. A type of branching.

slider device: a teaching machine to which the learner responds by moving a slider to construct his response from letters or numbers (Edwards, 1956).

snowballing: the technique of making items build up on each other to a complex concept.

socratic method: "A method of instruction which consists of a conversational quiz in which a tutor asks questions, the student replies, and the tutor confirms or denies the answer. If a response is incorrect the tutor leads the student by a series of questions to the correct response." (AID, 1962).

specifying item: an item which exemplifies a general rule through specific examples. See item (types) (Schutz, 1959).

stem: the leading phrase, in a multiple-choice or multiple-response item, which determines the correctness of the various foils.

step: (1) the interval from one item to the next. (2) syn. with item.

step density: the relative number of items required to effect a bond (Rigney and Fry, 1961).

step-size: theoretically the conceptual distance from one item to the next. Usually the average advance per item whithin a set and therefore a function of the number of items used to teach a certain concept (Galanter, 1959). See error probability. (Carr, 1959a) suggests two operational definitions: (a) the number of steps required to reach criterion. (b) the number of errors.

stimulus: material displayed to the learner in order to elicit a desired response. The stimulus includes text material, elicitor, and in multiple-choice items, response choices. The feedback after response is a stimulus directing further behavior.

stimulus device: a machine which conveys some information to the learner but does not provide feedback, e.g. a model, a projector (Porter, 1958). See teaching aid; response device; stimulus-response device.

stimulus impoverishment: the reduction of exposure time and/or illumination of a stimulus (Rothkopf, 1960). Compare continuous vanishing.

stimulus-response device: a machine which presents information and requires appropriate action (Porter, 1958): (a) Simulator: duplicates a complex task often without feedback. (b) Immediate reinforcer: provides feedback. (c) Pacer: presents materials and moves on regardless of response.

stimulus support: extra elements added to a stimulus to increase its distinctiveness and/or to increase the probability of eliciting a correct response.

story-board: a set of instructions and perhaps illustrations for photographic work in conjunction with the audio script necessary for producing a film (Weiss and Wulff, C. 1961).

straight-line programming: presentation of material so that every learner progresses through a single program. Syn. with extrinsic programming. Compare branching: intrinsic programming.

subject: the learner.

Subject-Matter Trainer: a multiple-choice teaching machine which displays problems singly and up to 20 response choices simultaneously (Briggs, 1959).

summation: a programming technique where all the bonds that have been learned in a particular set are combined in problem items to constitute a whole.

synchrony: "both stimuli and response change from item to item in the series, or neither the stimulus nor the response change from item to item. Example of the latter type is repetition." (AID, 1962)

tab-test: a test where feedback is furnished when the learner pulls a concealing tab off one of several response choices. See pull-tab device.

tape: syn with set.

teaching aid: a device which does not incorporate such functions as immediate feedback, and response control, e.g. projector, model. See automation of teaching.

teaching machine: See automation of teaching.

teaching machine (basic types) (Stolurow, 1959): (a) a non-adaptive machine presents a fixed pattern of materials and is experimenter paced. It does not adapt to the learner but does provide feedback; (b) a partially adaptive machine has feedback and keeps records of performance and may provide for drop-out; (c) an adaptive machine has the functions of (b) and capacity for branching.

teaching machine (components) (Carr, 1959b): (a) display, which presents the program; (b) response panel, which the learner uses in forming his response; (c) confirming mechanism, which provides learner with feedback; (d) reinforcement mechanism, which provides impetus for further operation of the device. Components (c) and (d) are often combined.

teaching machine (devices): for listing see Fry, Bryan, and Rigney (1960).

teaching machine (functions) (Stolurow, 1959): (a) presentation of the stimulus information and questions; (b) response mechanism to provide for overt measurable response; (c) comparator provisions to compare the learner's response with the criterion; (d) feedback mechanism to provide knowledge of results for every response; (e) programming provisions to present information in accordance with a defined set of rules; (f) pacing mechanism to allow for variability in the rate of presentation; (g) collator mechanism to combine learning and its measurement into a single set of operations; (h) selective mechanism which automatically drops out of a set the correctly responded-to items.

temac: "a brand name for a programmed text produced and sold by Encyclopedia Britannica Films, Inc." (AID, 1962)

terminal response or frame: "a response called for under conditions closely approaching those found on the job and/or a response made with minimum cues. Frames that contain such responses are sometimes called terminal (response) frames." (Shettel, Angell, and Lumsdaine, 1961).

terminal S-R connection: a stimulus connection which the programmer wishes to teach (Carr, 1959b). See bond.

test item: an item requiring a response for which the cues within the item are minimal (Galanter, 1959).

testing the limits: testing a learner for generalization and transfer (Galanter, 1959).

test-as-test stimulus: a confirming mode similar to test mode (Stephens, 1953).

test mode: a procedure wherein the learner is given one try at each item, with no feedback. Right and wrong responses are tallied. See confirming mode.

test trial: one effort by the learner to demonstrate mastery of a previously learned task. Usually no feedback is furnished.

test-book program: programmed material which presents the desired responses along with the stimulus requiring, therefore, no action other than reading by the learner.

test material: that part of an item which presents the material connecting previous learning to a new situation. See panel, defin. 1.

textual behavior: the learner's studying of information furnished in an item. See augmenting item; panel, defin. 1.

thematic prompt: a technique for eliciting a response by giving cues such as indicating categories, sublanguages, syntax, high association words, common phrases (Skinner, 1958). See lead-in item; Contrast formal prompt.

thinking response: a modification of covert response in which the learner is explicitly directed to think of the response he believes to be correct (Goldbeck et al, 1960).

track, multiple: "a provision within the programmed material for allowing subjects to pursue alternative sub-divisions of the program in terms of their successes or failures with earlier sections of the sequence." (AID, 1962)

track, single: "a common set of programmed materials which all subjects work through, there being no alternative program such as in the multiple track situation." (AID, 1962)

training trial: one effort by the learner to solve an item, usually with feedback. Compare test trial.

transitional S-R connection: a program step which can be expected to mediate the initial and terminal S-R connection, thus an intermediate step in a program (Carr, 1959b).

trial: (1) a single run-through on a set or series of items. (2) occasionally used to refer to one attempt at one item. Syn. with training trial.

Troubleshooting Trainer: a teaching machine using a system of logic circuits to indicate probabilities of effectiveness of corrective actions (Briggs, 1959).

two-pair item: a multiple-choice item with response choices presented in two sets, e.g. for material like vocabulary: Russian-a; English-b; English; Russian-b; the task might be to match the second Russian word with the corresponding English word, the other pair also being correct (Sevrin, 1955). See four-pair item.

unit response: syn. with fact (Skinner, 1959). See bond.

unmixed sequence a series of items where examples of the concept are given several times in close succession (Kurtz and Hovland, 1956). Compare mixed sequence.

unstable sequence: "refers to the arbitrary and unpredictable order between items in a paired-associates learning task such as learning a French-English vocabulary." (AID, 1962)

vanishing: (1) the reduction of stimulus supports in a sequence of items establishing a bond so as to link the stimulus, without support, to the correct response. Syn. with fading, cue reduction. See continuous vanishing. (2) gradual elimination of the stimulus of the initial S-R connection, leaving a connection between first transitional S-R connection and the response (Carr, 1959b) (3) a manner of presenting material where the learner is allowed one response, receives feedback, but does not have another opportunity at the item until the next time through (Stephens, 1953).

vanishing item: an item in which the stimulus support is less than that given in preceding items. See item (types) (Schutz, 1959); vanishing, defin. 1.

variable choice sequence: a group of items in which the number or format of the response choices is varied.

variable-sequence device: a machine which can variously arrange the presentation of new items depending on the learner's performance (Lumsdaine, 1959b). See branching; scrambled book.

variably blurred prompting: a technique of facilitating the learning of a bond in paired associates learning by allowing the learner gradually to clarify an out-of-focus prompt (Israel, 1960). Compare continuous vanishing. See prompt.

wash-back: the returning of a learner to material he had already worked through, thus a type of branching. See scrambled book; teaching machine (functions) (Stolurow, 1959).

weaning: the process of preparing the learner to utilize the material of a program outside of the training situation.

web of learning (Smith, 1959): (1) the programmed process by which introduced bonds are tied to existing bonds. (2) the product of the program - understanding by the learner.

write-in device: a teaching machine which requires the learner to write his response and compare it with a criterion response. See constructed response.

Glossaries of various levels of quality and completeness have appeared in several publications. Some of these have been used directly in this glossary, some have been only referred to. All of which I am aware appear below:

AID, Glossary of Terms. 1962, 2, 177-179.

Cook, Desmond L. Teaching Machine Terms. Audiovisual Instruction. 1961, 6, 152.

Foltz, Charles I. The World of Teaching Machines. Washington, D.C., Teaching Research and Technology Division, Electronic Teaching Laboratories, 1961. Pp. 67.

Markle, Susan Meyer. Mimeo. Glossary of Terms in Programmed Instruction. Center for Programmed Instruction, New York, 1962. Reproduced with slight changes in Audio Visual Communication Review, 1963, 11, 129.

Shettel, Harris H. Evaluation of Two Prototype Self-Instructional Programs Covering Basic Job Knowledge for Sage Track Monitor and Intercept Director Operator Positions. American Institute for Research, Pittsburg 32, Pennsylvania, March 1961, 31.

Shettel, Harris H., Angell, David, and Lumsdaine, Arthur A. Handbook for the Preparation of Self-Instructional Materials for Sage Operators. American Institute for Research, Pittsburg 32, Pennsylvania, April 1961, 55-56.

Shettel, Harris H. and Lumsdaine, Arthur A. Characteristics of Self-Instructional Devices to Meet Training Requirements for the Sage Track Monitor, Intercept Director and Related System Operator Positions. American Institute for Research, Pittsburg 32, Pennsylvania, March 1961, 45(a).

Shettel, Harris H. and Lumsdaine, Arthur A. Principles of Programing as Applied to the Development of Two Self-Instructional Programs. for Sage Operators. American Institute for Research, Pittsburg 32, Pennsylvania, March 1961, 18(b).

Teaching Machine and Programmed Learning. Glossary. NEA Journal, 1961, 50, 15.

BIBLIOGRAPHY*

AID, Glossary of Terms. 1962, 2, 177-179.

Barlow, John. Conversational Chaining in Teaching Machine Programms. Psychol. Rep., 1960, 7, 187-193. Earlham College, Richmond, Indiana. Under research project supported in part by a grant from the United States Office of Education. (Grant No. 7-12-026.00). Unpublished (circa 1960 b).

Barlow, John. Personal communication to M. P. Smith describing "Ebacher grill" and "scanning principle." Earlham College, Indiana. 2/22/1961

Briggs, L. J. Teaching machines, education, and job skill, Psychol. Rep., 1959, 5, 210 (a).

Briggs, L. J. Teaching machines for training of military personel in maintenance of electronic equipment. In Galanter, E. (Ed). Automatic Teaching: The State of the Art. New York: Wiley, 1959, p. 131-146 (b).

Briggs, L. J. Two self-instructional devices. Psychol. Rep., 1958, 4, 617-676.

Bryan, G. L., and Rigney, J. W. An Evaluation of a Method for Shipboard Training in Operations Knowledge. Technical report No. 18, Electronics Personnel Research Group, University of Southern California, September, 1956. (Fry, 1956).

Carr, W. J. A Review of the Literature on Certain Aspects of Automated Instruction. Report to Dr. J. Charles Jones, Dept. of Educ., Bucknell Univ. 1959 (a).

Carr, W. J. Self-Instructional Devices: A Review of Current Concepts. WADC Technical Report 59-503, Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio, August, 1959 (b).

---

* Bibliographical terms followed by (Carr, 1959a), (Carr, 1959b), (Fry, 1960) are summarized or referred to specifically in those materials and glossary items are based on those references. (Fry, 1960) refers to (Fry, Bryan, and Rigney, 1960).

Coulson, J. E. and Silberman, H. F. Automated teaching and individual differences, A V Comm. Rev., 1961, 9, 5-15.

Crowder, N. A. Automatic tutoring by means of intrinsic programming. In Galanter, E. (Ed). Automatic Teaching: The State of the Art. New York: Wiley, 1959, 109-116.

Edwards, W. Skinner's Teaching Machines. Laboratory Note, Maintenance Laboratory, AFPTRC, Air Research and Development Command, Lowry AFB, Denver Colorado, 1956 (Fry, 1960).

Eigen, L. D. The Construction of Frames of an Automated Teaching Program. Mimeo. Collegiate School Automated Teaching Project, New York. Revised 1960.

Fry, E. B., Bryan, G. L., and Rigney, J. W. Teaching machines: and annotated bibliography. Audio-Visual Communication Review, 1960, 8, No. 2, Suppl. 1.

Galanter, E. The ideal teacher. In Galanter, E. (Ed). Automatic Teaching: The State of the Art. New York: Wiley, 1959, p. 1-11.

Gilbert, T. F. An Early Approximation to Principles of Programming Continuous Discourse, Self-Instructional Materials. A Report to Bell Telephone Laboratories, Inc., Murray Hill, N. J., September, 1958 (Carr, 1959b).

Goldbeck, R. A. The Effect of Response Mode and Learning Material Difficulty on Automated Instruction. Tech. Report No. 1, Office of Navel Research Contract No. NONR-3077(00), American Institute for Research, Pittsburgh, Pa. Sept. 1960.

Goldbeck, R. A., Campbell, V. N. and Llewllyn, J. E. Further Experimental Evidence on Response Modes in Automated Instruction. Tech. Report No. 3. Office of Navel Research. Contract NONR-3077(00). Amer. Institute for Research, Pittsburg, 32, Pa. Dec. 1960.

Griffith, B. C. Variables in Automatic Teaching. Unpublished paper, Edward R. Johnstone Training and Research Center, Bordentown, N. J., June, 1960.

Gustafson, H. W. Intrinsic programming developments, Teaching-Machine Conference Proceedings, (Mimeo) Univ. of So. Calif., 19 October 1960, 12-18.

Holland J. G. Teaching Machines: An Application of Principles from the Laboratory. Paper presented at the Invitational Conference of the Educational Testing Service, October, 1959.

Hively, W. An Exploratory Investigation of an Apparatus for Studying and Teaching Visual Discrimination, using Pre-School Children. Unpublished paper reporting research under a grant from Carnegie Corporation under direction of B. F. Skinner, Circa 1960.

Homme, L. E. and Glaser, R. Relationships between the Programmed textbook and teaching machines. In Galanter, E (Ed). Automatic Teaching: The State of the Art. New York: Wiley, 1959, p. 103-108.

Irion, A. L. and Briggs, L. J. Learning Task and Mode of Operation Variables in the Use of the Subject-Matter Trainer. Technical Report, AFPTRC TR 57-8 Air Force Personnel and Training Research Center, Lackland Air Force Base, Texas, October, 1957. (Fry, 1960).

Israel, M. L. Variably blurred prompting: I. Methodology and application to the analysis of paired-associate learning. J. Psychol., 1960, 50, 43-52.

Keislar, E. R. Preliminary Report on project to teach mathematics and molecular theory to first graders using teaching machines. Teaching-Machine Conference Proceedings. Univ. of So. Calif., 19 October 1960, 1-3.

Kurtz, K. H. and Hovland, C. I. Concept learning with different sequences of instances. J. Exp. Psychol. 1956, 51, 239-243.

Lumsdaine, A. A. Partial and more complete automation of teaching in group and individual situations. In Galanter, E. (Ed). Automated Teaching: The State of the Art. New York: Wiley, 1959, 147-166 (a).

Lumsdaine, A. A. Teaching machines and self-instructional materials. Audio-Visual Communication Review. 1959, 7, 163-181 (b).

Lumsdaine, A. A., and Klaus, D. J. What's in a Name? Unpublished paper, American Institute for Research, Pittsburg 32, Pennsylvania. June, 1960.

Markle, Susan. Mimeo. Glossary of Terms in Programmed Instruction. Center for Programmed Instruction, New York, 1962. Reproduced with slight changes in Audio Visual Communication Review, 1963, 11, 129.

Miller, R. B. Psychological Considerations for the Design of Training Equipment. WADC Techn. Report 54-563, Air Research and Development Command, Wright-Patterson AFB, Ohio, December, 1954 (Fry, 1960).

Peterson, J. C. A new device for teaching, testing and research on learning. Trans. Kan. Acad. Sci., 1930, 33, 41-47 (Fry, 1960).

Porter, D. Some effects of year long teaching machine instruction. In Galanter, E. (Ed). Automatic Teaching: The State of the Art. New York: Wiley, 1959, p. 85-90.

Porter, D. Teaching machines. Harv. Grad. Sch. of Educ. Assoc. Bull. 1958, 3, 1-5 (Fry, 1960).

Pressey, S. L. Development and appraisal of devices providing immediate automatic scoring of objective tests and concomitant self-instruction. J. Psychol. 1950, 29, 417-447.

Rigney, J. W., and Fry, E. B. A survey and analysis of current teaching-machine programms and programming. Department of Psychology, Univ. of So. Cal. Contract NONR-228(22) (Mimeo) February 1961.

Rothkopf, E. Z. Two predictors of stimulus equivalence in Paired-associates learning. Psychol. Reports, 1960, 7, 241-250. (1960b).

Schutz, R. E. Progress in preparation of automated instructional material and criterion measures. Automated Teaching Bulletin. 1959, 1, 31-33.

Sevrin, D. G. Appraisal of special tests and procedures used with self-scoring instructional testing devices. Abstracts of Doctoral Dissertations. No. 65. Ohio State University, 1955 (Fry, 1960).

Shettel, Harris H. Evaluation of Two Prototype Self-Instructional Programms Covering Basic Job Knowledge For SageTrack Monitor and Intercept Director Operat or Positions. American Institute for Research, Pittsburg 32, Pennsylvania, March 1961, 31.

Shettel, Harris H., Angell, David, and Lumsdaine, Arthur A. Handbook for the Preparation of Self-Instructional Materials for Sage Operators. American Institute for Research, Pittsburg 32, Pennsylvania, April 1961, 55-56.

Shettel, Harris H. and Lumsdaine, Arthur A. Characteristics of Self-Instructional Devices to Meet Training Requirements for the Sage Track Monitor, Intercept Director and Related System Operator Positions. American Institute for Research, Pittsburg 32, Pennslvania, March 1961, 45 (a).

Shettel, Harris H. and Lumsdaine, Arthur A. *Principles of Programming as Applied to the Development of Two Self-Instructional Programms for Sage Operators*. American Institute for Research, Pittsburg 32, Pennsylvania, 18 (b).

Skinner, B. F. The programming of verbal knowledge. In Galanter, E. (Ed). *Automatic Teaching: The State of the Art*. New York: Wiley, 1959, p. 63-68.

Smith, D. E. P. Speculations: Characteristics of successful programs and programmers. In Galanter, E. (Ed). *Automatic Teaching. The State of the Art*. New York: Wiley, 1959, p. 91-102.

Stephens, L. Certain special factors involved in the law of effect. *Abstracts of Doctoral Dissertations, No. 64*. Ohio State University, 1953 (Fry, 1960).

Stolurow, L. M. *Teaching Machines and Special Education*. Paper read at Peabody Conference on Research in Mental Retardation, Montgomery Bell, Tennessee, February, 1959.

Stolurow, L. M. and Hasterok, G. S. *Principles for Programming Learning Materials* in Self-Instructional Devices for Mentally Retarded Children. Unpublished paper, 1960.

Weiss, E. C. and Wulff, J. J. *Design and Evaluation of a Self-Tutoring Method for On-site Training in Sage*, AN/FST - 2 Trouble - Shooting, II. A revised program. AF CCDD-TN-60-61. Psychological Research Associates, Arlington 2, Virginia. PRA Report 61-1. c(1961).

Willey, C. F. *Multiple-Response: A Neglected Item Form*. Unpublished paper. Norwich University, c1959 (Mimeo).

Appendix A

Alphabetical List of All Words in the Program

A

- a
- and
- at

B

- baby
- ball
- be
- beautiful
- bed
- bell
- bicycle
- big
- birthday
- black
- blanket
- blow
- blue
- book
- boy
- bread
- break
- broom
- brother
- butter

C

- cake
- can
- car
- cat
- chicken
- children
- choose
- church
- clean
- climb
- clock
- close
- closet
- coat
- color
- cross
- cry
- cute

D

- dark
- day
- dentist
- dime
- dinner
- dirty
- do
- dog
- doll
- dollar
- don't
- door
- draw
- dress
- drink
- drop
- drum

F

- face
- family
- fast
- fat
- father
- feet
- fire
- fireman
- first
- flame
- floor
- flower
- fly
- for
- fox
- Friday
- friend
- from
- fruit

G

- game
- garage
- gasoline
- gate
- get
- girl
- give
- glad
- glass
- gloves
- glue
- go
- goat
- goes
- good
- goodbye
- grandmother
- grass
- gray
- green

H

- hair
- hand
- happy
- has
- hat
- have
- he
- her
- here
- high
- him
- his
- horse
- house
- hungry
- hurt

I

- I
- in

J

- jacket
- jail
- janitor
- jar
- jelly
- jewelry
- judge
- jump

K

- keep
- kettle
- key
- kind
- king
- kiss
- kitchen
- kite

L

- ladder
- lady
- lamp
- late
- learn
- letter
- like
- lion
- little
- long
- look

M

- make
- me
- meet
- milk
- monkey
- moon
- mother
- mouse
- movies
- mile

cookies
cost
count
cracker
crib

N

nail
name
needs
new
newspaper
nickel
night
not
nurse

O

on
out

P

paint
paper
pencil
picture
pie
pill
plant
play
please
policeman
pony
porch
postman
pot
president
pretty
print
prize
pupil
puppy
pure

Q

quarter

fun
funeral

road
robber
room
rug
run

S

salt
school
see
send
she
shelf
shoes
show
shut
sing
sister
six
sled
sleep
sleeve
small
smile
smoke
smooth
snow
soft
soup
spelling
spend
spoon
spot
step
stick
stone
stove
straw
street
string

is
it

the
thank
there
this
three
thumb
Thursday
to
track
train
tree
trip
truck
try
turkey
turn

U

United States
us
use

V

vacation
valentine
vegetable
very
violin
visitor
voice
vote

W

wagon
was
we
wet
wheel
where

museum
music
my

yellow
yes
you
your

Z

zebra
zero
zipper
zoo

queen
quick
quiet

R

rabbit
radio
read
red
ribbon
ride
right

strong
study
sun

T

table
take
talk
taste
teacher
teeth
ten

whistle
white
wife
window
with
wood
wrap
wrench
wrist
write

Y

yard

APPENDIX B

The Reading Program

Unit 1

Subunit 1

Groupings (Sight Recognition)

Lesson:

1	2	3	4	5
ball	big	boy	birthday	fire
car	cost	cake	coat	count
dirty	dog	day	doll	dollar
fat	father	is	fun	it

6	7	8	9	10
book	beautiful	the	bed	baby
color	cat	cookies	count	has
dime	door	face	dark	cost
first	a	on	family	fireman

Subunit 2

Sentences (Word Meaning)

Lesson:

1

The ball is big.
It is a beautiful day.
A dog is fun.
The baby has a birthday cake.

2

Color the first book.
The boy has a dollar.
Cookies cost a dime.
The doll has a dirty face.

3

The cat is on the bed.
Count the cookies.
The boy has a coat.
The baby is fat.

4

The family has a beautiful car.
The door is a dark color.
The car is on fire.
Father is a fireman.

Subunit 3

Phonics (initial consonant sounds b, c, d, f)

Lesson:

1	2	3	4	Helping Words
ball	car	dog	fireman	the
bed	coat	door	face	has
book	cat	dollar	family	it
boy	cake	doll	father	is
big	cookies	dirty	fat	on
birthday	cost	dime	fun	a
baby	color	day	fire	(cost)
beautiful	count	dark	first	(count)

Unit 2

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4	5
	girl	kite	jump	jelly	gate
	hurt	to	key	get	house
	janitor	gasoline	his	high	jar
	in	hand	garage	king	can

	6	7	8	9	10
	was	jail	my	goat	game
	kettle	kitchen	jacket	hair	jewelry
	horse	her	kiss	keep	hat
	good	goodbye	happy	judge	kind

Subunit 2

Sentences (Word Meaning)

1

Gasoline is in the garage.
Get the key to the house.
Jelly is in the jar.
The kettle is in the kitchen.

2

The janitor hurt his hand.
The horse can jump.
The king is happy.
A goat has hair.

3

The girl has jewelry.
It is a good jacket.
Kiss her goodbye.
Keep the hat.

4

The kite is high
The jail has a gate.
The judge is kind.
It was my game.

Subunit 3

Phonics (initial sounds g, h, j, k)

Lesson:	1	2	3	4	Helping Words
	girl	hand	jar	kite	in
	garage	house	jail	key	his
	gate	horse	jacket	king	get
	goat	hat	jewelry	kettle	to
	gasoline	hurt	janitor	kitchen	can
	good	high	jump	kind	her
	goodbye	happy	jelly	kiss	was
	game	hair	judge	keep	my

Unit 3

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4	5
	lion	nurse	pencil	nail	monkey
	have	letter	newspaper	policeman	nickel
	milk	mother	mouse	gave	puppy
	pony	she	lamp	me	with

	6	7	8	9	10
	little	out	please	me	moon
	meet	long	we	learn	at
	name	movies	look	needs	play
	postman	new	night	pretty	ladder

Subunit 2

Sentences (Word Meaning)

1

The mouse is little.
The monkey is on the ladder.
Look at the pony.
It is a big lion.

2

Get her the pencil.
The nurse gave me a pill.
Learn her name.
The moon is out at night.

3

She is my mother.
We have a new lamp.
Meet me at the movies.
The postman gave her a letter.

4

Paint the porch.
The newspaper is a nickel.
The puppy needs milk.
It is a long nail.

Subunit 3

Phonics (initial sounds: l, m, n, p)

Lesson:	1	2	3	4	New helping words
	lion	milk	nurse	pony	have
	letter	mother	newspaper	pencil	she
	lamp	mouse	nail	policeman	gave
	ladder	monkey	nickel	puppy	with
	little	meet	name	postman	out
	long	movies	new	pill	we
	look	me	night	paint	at
	learn	moon	needs	porch	(me)

Unit 4

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4	5
	see	room	ribbon	road	violin
	radio	sing	soft	send	us
	table	turkey	teeth	teacher	read
	vote	voice	he	him	school

	6	7	8	9	10
	valentine	very	talk	right	fast
	you	like	vegetable	salt	red
	soup	run	sister	turn	visitor
	take	taste	right	vacation	talk

Subunit 2

Sentences (Word Meaning)

1

My sister is on vacation.
Sing with us.
She has very good teeth.
He has a soft voice.

2

Taste the vegetable soup.
The salt is on the table.
I like turkey.
Talk to the visitor.

3

We read in school.
The teacher has a violin.
Send her a valentine.
Vote for him.

4

You can run fast.
Take the right road.
See the red ribbon.
Turn on the radio.

Subunit 3

Phonics (initial sounds: r, s, t, v)

Lesson:	1	2	3	4	*New helping words*
	radio	school	table	violin	he
	room	salt	turkey	valentine	him
	ribbon	sister	teeth	vegetable	us
	road	soup	teacher	visitor	you
	read	see	take	vote	fast
	run	sing	talk	voice	like
	red	soft	taste	very	(right)
	right	send	turn	vacation	(talk)

Unit 5

Subunit 1

Groupings (Sight Recognition)

Lesson: 1	2	3	4	5
this	window	zipper	yes	zero
wagon	yellow	quiet	zoo	wife
yard	queen	I	there	quarter
zebra	here	wood	quick	your

Subunit 2

Sentences (Word Meaning)

1

Look in the window.
It is quiet in the house.
She is a beautiful queen.
I see your wife.

2

Take her to the zoo.
Yes, it is a baby zebra.
He gave me a quarter.
The coat has a zipper.

3

Here is a red wagon.
There is wood in the yard.
Quick, get the dog.
I have a yellow pencil.

Subunit 3

Phonics (initial sounds: q, w, y, z)

Lesson: 1	2	3	4	Helping words
quarter	wagon	yard	zebra	here
queen	window	yellow	zipper	there
quiet	wood	yes	zoo	I
quick	wife	your	zero	this

Story 1 - Words from Units 1 to 5

KING

I have a dog.
King is his name.
He is a police* dog.
Father gave it to me.
My dog is very big.
He is beautiful.
He is kind.

Oral Instructions:

1. The name of this story is King. It is a story about a police dog.
2. Read it carefully to yourself.
3. Press the top button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

What is the dog's name?

King
Boy
Judge
Lion

Press the button next to the right one.

The next question is:

What kind of dog is he?

a mother dog
a little dog
a police dog
a small dog

Press the button next to the right one.

The next question is:

Who gave me the dog?

sister
teacher
mother
father

Press the button next to the right one.

The last question is:

How does my dog look?

dark
beautiful
little
fat

Press the button next to the right one.

---

*The word "police" was not taught in the program. This is an inadvertant error. The word "policeman" was taught, however.

Story 2 - **Words from Units 1 to 5**

MY DOG KING

King is my dog.
He is with me day and night.
At night he is on my bed.
I take him on my vacation.
I like King.

Oral Instructions:

1. The name of this story is My Dog King.
2. Read the story carefully to yourself.
3. Press the top button when you have finished reading it.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about it after you have finished.
5. Press the top button when you have finished reading.

Where do I keep King at night ?

in school
by the table
on my bed
in the garage

Where do I take King ?

on my vacation
in the kitchen
to the house
to the movies

Where is King during the day ?

with the fireman
with my sister
with the post man
with me

PRECEDING PAGE BLANK- NOT FILMED

Story 4 - Words from Units 1 to 5

VEGETABLE SOUP

Mother is in the kitchen.
The soup is in the kettle.
It is vegetable soup.
It needs a little salt.
The boy and girl taste the soup.
It is very good.

Oral Instructions:

1. The name of this story is Vegetable Soup.
2. Read the story carefully to yourself.
3. Press the top button when you have finished reading it.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

What is mother making?	soup cookies cake jelly
What kind of soup is it?	turkey vegetable
What does the soup need?	milk vegetable salt
Who are tasting the soup?	mother and father boy and girl cat and dog teacher
Is the soup good?	no yes

Story 5 - Words from Units 1 to 5

MARY'S BIRTHDAY

It is Mary's birthday.
Mother gave her a little cat.
The cat is yellow.
It is soft and beautiful.
Mary is very happy.

Oral Instructions:

1. The name of this story is Mary's Birthday.
2. Read the story carefully to yourself.
3. Press the top button when you have finished reading it.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about it after you have finished.
5. Press the top button when you have finished reading.

It is somebody's birthday. Name her.

sister
Mary
mother
teacher

What did mother give her ?

big puppy
little monkey
happy dog
little cat

What kind of a cat is it ?

dark
red
yellow
big

Did Mary like her present ?

yes

no

Story 6 - Words from Units 1 to 5

BOOKS

Books can be fun.
There are little books and big books.
There are books to read.
Mother and father read books to us.

Oral Instructions:

1. The name of this story is Books.
2. Read the story carefully to yourself.
3. Press the top button when you have finished reading it.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about it after you have finished.
5. Press the top button when you have finished reading.

What are books for?	to run to read to vote to sing
Who read books to us?	boy and girl teacher sister mother and father
What kinds of books are there?	little and big fat and dirty soft and beautiful

Story 7 - Words for Units 1 to 5

THE BIG FIRE

There is a big fire.
The fire is in the garage.
Gasoline is on fire.
Here is a fireman.
He has a ladder.
The fire is out.

Oral Instructions:

1. The name of this story is The Big Fire.
2. Read the story carefully to yourself.
3. Press the top button when you have finished reading it.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about it when you have finished.
5. Press the top button when you have finished reading.

Where is the fire?	in the garage in the house in the zoo in the kitchen
What is on fire?	bed doll gasoline table
Who has come to help?	teacher fireman sister mother
What is the fireman carrying?	book kettle ladder valentine
Is the fire still burning?	yes no

UNIT 6

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4	5
	brother	cross	from	not	dress
	crib	drink	draw	break	go
	fruit	friend	cry	drum	broom
	do	for	bread	Friday	cracker

Subunit 2

Sentences (Word Meaning)

Lesson: 1

Baby brother is in the crib.
I like your dress.
Draw a cross with your pencil.
My friend is here.

2

Drink your milk .
Fruit is good for you.
I go to the movies on Friday.
I have a new drum.

3

Bread is on the table.
Do not break the broom.
Take the cracker from the table.
My doll can cry.

Subunit 3

Phonics (initial blends, br, cr, dr, fr)

Lesson:	1	2	3	4	Helping Words
	brother	cross	dress	fruit	do
	bread	cry	drink	friend	go
	break	crib	draw	Friday	for
	broom	cracker	drum	from	not

UNIT 7

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4
	green	wrench	president	gray
	pretty	try	truck	wrist
	train	prize	wrap	trip
	write	grass	grandmother	print

Subunit 2

Sentences (Word Meaning)

Lesson: 1

The grass is green.
Wrap up the prize.
It is a long trip.
Write a letter.

2

Grandmother is in the kitchen.
She is a pretty nurse.
Look at the red truck.
My father has a new wrench.

3

The boy hurt his wrist.
The president is on the train.
Try to print your name.
I have a gray coat.

Subunit 3

Phonics (initial blends, gr, pr, tr, wr)

Lesson:	1	2	3	4
	grass	president	train	wrist
	grandmother	prize	truck	wrench
	gray	print	try	write
	green	pretty	trip	wrap

UNIT 8

Subunit 1

Groupings (Sight Recognition)

Lesson: 1	2	3	4	5	6
black	play	please	clock	plant	plate
closet	sled	glad	glue	slow	close
flower	clean	fly	flame	floor	sleeve
glass	blue	blanket	sleep	blow	gloves

Subunit 2

Sentences (Word Meaning)

Lesson: 1

The blanket is in the closet.
Clean the floor.
The girl has blue gloves.
Blow out the flame.

2

Please go to sleep.
I have a black sled.
I am glad to play with you.
The clock is slow.

3

A fly is on my sleeve.
Plant the flower here.
It is a glass plate.
Close the jar of glue.

Subunit 3

Phonics (initial blends bl, cl, fl, gl, pl, sl)

Lesson: 1	2	3	4	5	6
black	clock	flower	glass	plant	sled
blanket	closet	floor	glad	plate	sleeve
blue	clean	flame	gloves	please	sleep
blow	close	fly	glue	play	slow

UNIT 9

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4
	step	spoon	stick	string
	straw	strong	spelling	study
	spend	smoke	street	spot
	small	smooth	stone	smile

Subunit 2

Sentences (Word Meaning)

Lesson: 1

Study your spelling.
It is a small spot.
There is a smile on his face.
His spoon is in the soup.

2

I see black smoke.
The girl has a straw hat.
He spent the dime on cookies.
Do not step on the stick.

3

The stone is smooth.
My father is strong.
Mother has a ball of string.
The street is dirty.

Subunit 3

Phonics (initial blends st, str, sp, sm)

Lesson:	1	2	3	4
	step	street	spot	smoke
	stick	straw	spoon	smile
	stone	strong	spend	smooth
	study	string	spelling	small

UNIT 10

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2	3	4
	church	whistle	show	Thursday
	shoes	thumb	thank	where
	three	shelf	choose	shut
	wheel	chicken	white	children

Subunit 2

Sentences (Word Meaning)

Lesson: 1

I like chicken.
The children are in bed.
We go to church.
Turn the wheel with your thumb.

2

Choose three boys to play.
Show her the shoes.
Thank you for the book.
The policeman has a whistle.

3

The radio is on the shelf.
Shut the door.
I hurt my hand on Thursday.
I see where my ball is.

Subunit 3

Phonics (initial digraphs ch, sh, th, wh)

Lesson:	1	2	3	4
	church	shoes	three	wheel
	chicken	shelf	thumb	whistle
	choose	show	thank	white
	children	shut	Thursday	where

Story 1 - Words from Units 1-10

A New Dress

I have a new dress.
The color of the dress is blue.
My grandmother gave it to me.
It is very pretty.
I keep it in my closet.

Oral Instructions:

1. The name of the story is A New Dress.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read:
The first question is:

Who gave me the new dress?

Press the button next to who gave me the dress.

grandmother
father
mother
baby

The next question is:

What color is it?

Press the button next to the right answer.

black
green
blue
red

The last question is:

Where do I keep it?

Press the button next to the right answer.

on my bed
in my closet
in the car
on the shelf

Story 2 - Words from Units 1-10

My Train

I have a small train.
It is black and white.
My friend and I play with it.
It has a whistle.
I blow the whistle.
My train can go fast.

Oral Instructions

1. The name of the story is My Train.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

What do I have?

a truck
a wrench
a train
a broom

Press the button next to the right answer.

The next question is:

What do I blow?

the flower
the whistle
the fruit
the plant

Press the button next to the right answer.

The next question is:

Who plays with me?

the president
my grandmother
my brother
my friend

Press the button next to the right answer.

The last question is:

Does my train go fast?

yes
no

Press the button next to the right answer.

16

Story 3 - Words from Units 1-10

My Baby Brother

My brother is a baby.
He has to sleep in a crib.
I wrap him in a blue blanket.
I like to play with him.
I show him my train and truck.
He is happy.

Oral Instructions

1. The name of the story is My Baby Brother.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Is the baby a boy or girl?

girl
boy

Press the button next to the right answer.

The next question is:

Where does he sleep?

in a crib
on the grass
in a truck
on the shelf

Press the button next to the right answer.

The next question is:

What color is his blanket?

black
green
blue
white

Press the button next to the right answer.

The last question is:

What do I show him?

bread and cracker
flower and fruit
glass and spoon
train and truck

Press the button next to the right answer

Story 4 - Words from Units 1-10

Grandmother's House

We go to visit my grandmother
We go on a train.
She has a small house.
We see green grass in the yard.
We see pretty flowers.
We like to visit her.

Oral Instructions

1. The name of the story is Grandmother's House.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Who do we go to visit?

Press the button next to the right answer.

children
a friend
a grandmother
my brother

The next question is:

What kind of house is it?

Press the button next to the right answer.

small
blue
clean
white

The last question is:

What do we see in the yard?

Press the button next to the right answer.

fruit and bread
drum and dress
wrench and wheel
grass and flowers

Story 5 - Words from Units 1-10

Spot

I have a new puppy.
He is very small.
He likes to play in the grass.
He plays with a big ball.
He is black with a white spot.
His name is Spot.

Oral Instructions

1. The name of the story is Spot. It is a story about a puppy.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Where does the puppy play?

Press the button next to the right answer.

in the street
on the floor
in the grass
on the step

The next question is:

What does he play with?

Press the button next to the right answer.

a dirty doll
a small kite
a red truck
a big ball

The next question is:

What color is he?

Press the button next to the right answer.

green
black
blue

The last question is:

What is his name?

Press the button next to the right answer.

Spot
King
Queen

Story 6 - Words from Units 1-10

Fun In My Room

I like to play in my room.
There is a radio in it.
I play with my train and truck.
My brother plays with me.
We have fun in my room.

Oral Instructions

1. The name of the story is Fun In My Room.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story you have just read.

The first question is:

Where do I like to play?

Press the button next to the right answer.

in the street
in my room
in school
in the closet

The next question is:

What is in my room?

Press the button next to the right answer.

a broom
a violin
a sled
a radio

The next question is:

Who plays with me?

Press the button next to the right answer.

my brother
the children
my grandmother
my friend

The last question is:

Do we have fun?

Press the button next to the right answer.

no
yes

Story 7 - Words from Units 1-10

My Red Wagon

I have a little wagon.
It is red with black wheels.
It can go fast.
I keep it in the garage.
My father keeps his car there.
The wagon is my car.

Oral Instructions

1. The name of the story is My Red Wagon.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished reading.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

What kind of wagon do I have?
Press the button next to the right answer.

little red wagon
big green wagon
new white wagon

The next question is:

Can it go fast?
Press the button next to the right answer.

no
yes

The last question is:

Where do I keep it?
Press the button next to the right answer.

in the closet
in the room
in the kitchen
in the garage

UNIT 11

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	baby	paper
	cake	lady
	late	take
	play	make

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	Make the bed.	We go to bed late.
	Kiss the baby.	My brother has a birthday cake.
	The paper is on the porch.	We play in the yard.
	Take the wrench to father.	The lady has jewelry.

Subunit 3

Phonics (Long a vowel sound)

Lesson 1:

baby
paper
late
make
lady
cake
tape
play

UNIT 12

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	cat	track
	trap	blanket
	and	ladder
	fat	rabbit

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	It is a long ladder.	My truck is red and black.
	The cat is in the house.	She is a fat baby.
	The rabbit runs fast.	The train is on the track.
	Try to trap the lion.	I have a blue blanket.

Subunit 3

Phonics (Short a vowel sound)

Lesson 1:

cat*
track
blanket*
trap
rabbit
ladder*
and
fat*

*Repeated from earlier units

UNIT 13

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	be	museum
	feet	we
	zebra	she
	key	tree

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	The museum is clean.	There is a zebra in the zoo.
	My feet are dirty.	The key cost a dime.
	We have a new car.	Please be quiet.
	The kite is in the tree.	She is good.

Subunit 3

Phonics (Long e vowel sound)

Lesson 1:

tree
key*
we*
museum
she*
feet
zebra*
be

*Repeated from earlier units.

UNIT 14

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	wet	dress
	bed	dentist
	bell	jelly
	ten	yes

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	Go to bed.	Yes, the postman gave me a letter.
	It is a big bell.	My dress is new.
	The jelly tastes good.	I go to the dentist today.
	I have ten cookies.	The paint is wet.

Subunit 3

Phonics (Short e vowel sound)

Lesson 1:

bed*
dentist
jelly*
ten
bell
dress*
yes*
wet

*Repeated from earlier units.

UNIT 15

Subunit 1

Groupings (Sight Recognition)

Lesson:

1	2
bicycle	like
pie	kite
ride	fireman
climb	write

Subunit 2

Sentences (Word Meaning)

Lesson:

1	2
The kite can fly.	Write your name here.
I have a bicycle.	My brother is a fireman.
Climb the ladder.	It is a fruit pie.
I like vegetable soup.	I ride in the car.

Subunit 3

Phonics (Long i vowel sound)

Lesson 1:

kite*
bicycle
climb
like*
fireman*
pie
write*
ride

*Repeated from earlier units.

UNIT 16

Subunit 1

Groupings (Sight Recognition)

Lesson:

1
dinner
give
this
little

2
window
six
chicken
picture

Subunit 2

Sentences (Word Meaning)

Lesson:

1
The window is dirty.
Give me the pencil.
The puppy is little.
I have six new pencils.

2
Show me the picture.
This is my book.
The chicken is in the yard.
We have soup for dinner.

Subunit 3

Phonics (Short i vowel sound)

Lesson 1:

window*
picture
give
little*
chicken*
six
this*
dinner

*Repeated from earlier units.

UNIT 17

Subunit 1

Groupings (Sight Recognition)

Lesson:

1	2
goes	close
yellow	snow
radio	don't
stove	go

Subunit 2

Sentences (Word Meaning)

Lesson:

1	2
The stove is in the kitchen.	Close the window.
I have a yellow coat.	My sister goes to school.
Don't play in the street.	We like the snow.
Go to the store.	Get the radio from mother.

Subunit 3

Phonics (Long o vowel sound)

Lesson 1:

stove
yellow*
don't
go*
radio*
snow
goes*
close*

*Repeated from earlier units.

UNIT 18

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	doll	on
	fox	clock
	robber	drop
	pot	dollar

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	A robber is in my house.	Look at the fox.
	I have a new doll.	Do not drop the glass.
	The house is on fire.	Here is a dollar.
	The soup is in the pot.	The clock is fast.

Subunit 3

Phonics (Short o vowel sound)

Lesson 1:

- doll*
- pot
- robber
- on*
- fox
- clock*
- drop
- dollar*

*Repeated from earlier units.

UNIT 19

Subunit 1

Groupings (Sight Recognition)

Lesson:	1	2
	cute	pure
	music	mule
	pupil	funeral
	United States	use

Subunit 2

Sentences (Word Meaning)

Lesson:	1	2
	He is a cute puppy.	The pupil is in school.
	The milk is pure.	I see a funeral.
	We like music.	The mule is hurt.
	Use the new pencil.	We like the United States.

Subunit 3

Phonics (Long u vowel sound)

Lesson 1:

mule
United States
funeral
use
pupil
music
cute
pure

UNIT 20

Subunit 1

Groupings (Sight Recognition)

Lesson:

1	2
drum	butter
sun	truck
jump	fun
hungry	rug

Subunit 2

Sentences (Word Meaning)

Lesson:

1	2
I like butter on my bread.	It is fun to play ball.
This truck is very big.	My dog is hungry.
Look at the sun.	The rug is gray and green.
My new drum is big.	The boy can jump high.

Subunit 3

Phonics (Short u vowel sound)

Lesson 1:

- drum
- butter*
- fun
- hungry*
- truck*
- sun
- jump*
- rug

*Repeated from earlier units.

Story 1 - Words from Units 1-20

Mary's Doll

Mary has a new doll.
A friend gave it to her.
The doll has a green dress.
Her hair is long.
Mary likes to play house with her doll.
She is glad to have a pretty doll.

Oral Instructions

1. The name of the story is Mary's Doll.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

What does Mary have?

Press the button next to the right one.

cat
chicken
radio
doll

The next question is:

Who gave Mary the doll?

Press the button next to the right one.

president
lady
friend
dentist

The next question is:

What color is the doll's dress?

Press the button next to the right one.

green
red
black
gray

The last question is:

What kind of hair does the doll have?

Press the button next to the right answer.

wet
yellow
strong
long

Story 2 - Words from Units 1-20

The President

The president has his picture in the newspaper.
He is the president of the United States.
He is with a lady.
The lady is his wife.

Oral Instructions

1. The name of the story is The President.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Whose picture is in the newspaper?

dentist
president
postman
robber

Press the button next to the right one.

The next question is:

Who is with the president?

a fireman
a man
a pupil
a lady

Press the button next to the right one.

The last question is:

Who is the lady?

his mother
his sister
his wife
his grandmother

Press the button next to the right answer.

Story 3 - Words from Units 1-20

My Bicycle

I have a new bicycle.
It has blue wheels.
I ride it in the street.
It can go very fast.
I gave my brother a ride.
I keep my bicycle clean.

Oral Instructions

1. The name of the story is My Bicycle.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Who rides my bicycle besides me?

sister
dentist
brother
lady

Press the button next to the right one.

The next question is:

What color are the bicycle wheels?

yellow
blue
green
red

Press the button next to the right one.

The next question is:

Where do I ride my bicycle?

in the garage
in the house
in the street
in the yard

Press the button next to the right one.

The last question is:

How do I keep my bicycle?

dirty
clean
wet
dark

Press the button next to the right one.

Story 4 - Words from Units 1-20

Black Smoke

I see black smoke.
There is a small fire in the school.
I see a big ladder.
Three firemen are on the ladder.
They are good firemen.

Oral Instructions

1. The name of the story is Black Smoke.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Where is the fire?

Press the button next to the right one.

in the school
in the truck
in the bed
in the stove

The next question is:

How many firemen are on the ladder?

Press the button next to the right one.

four
one
two
three

The next question is:

What color is the smoke?

Press the button next to the right one.

yellow
red
black
white

The last question is:

What kind of fire is it?

Press the button next to the right one.

small
big
fast
high

Story 5 - Words from Units 1-20

A Letter

I have a letter.
It is from my friend.
He is on vacation.
He is with his family.
They have fun.
I go on my vacation Friday.

Oral Instructions

1. The name of the story is A Letter.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

Who sent the letter?

Press the button next to the right one.

mother
friend
girl
pupil

The next question is:

Where is my friend?

Press the button next to the right one.

on the street
on the porch
on radio
on vacation

The next question is:

Who is with my friend?

Press the button next to the right one.

family
dog
lady
dentist

The last question is:

When do I go on my vacation?

Press the button next to the right answer.

Thursday

Friday

Story 6 - Words from Units 1-20

A New Radio

My brother has a new radio.
He is very happy.
He likes to play it in his room.
I climb on his bed.
We have fun with the radio.

Oral Instructions

1. The name of the story is A New Radio.
2. Read it carefully to yourself.
3. Press the button when you have finished reading.
   (pause - 2 min.)
4. Now read the story aloud. Read it carefully because I will ask you questions about the story after you have finished.
5. Press the top button when you have finished reading.

I am now going to ask you some questions about the story that you have just read.

The first question is:

	sister
Who has a new radio?	baby
	friend
Press the button next to the right one.	brother

The next question is:

	in his room
Where does he play the radio?	in the museum
	on his bicycle
Press the button next to the right one.	in the truck

The last question is:

	ride a bicycle
What do I do in his room?	play a game
	climb on bed
Press the button next to the right answer.	have my dinner

APPENDIX C

The Arithmetic Program

Unit I - From Discrimination

A-O Recognition of basic shapes: circle, square, rectangle, triangle

Unit II - Number Recognition

A-1 Numbers 1 thru 4
A-2 Numbers 5 thru 7
A-3 Numbers 8 thru 10

Unit III - Rote Counting

A-4 Number sequence 1 thru 4
A-5 Number sequence 5 thru 7
A-6 Number sequence 8 thru 10

Unit IV - Rational Counting

A-7a Enumeration 1 thru 2
A-7b Enumeration 3 thru 4
A-8 Enumeration 5 thru 7
A-9 Enumeration 8 thru 10

Unit V - Simple Addition

A-10 $\begin{array}{r}1\\+1\\\hline\end{array}$ $\begin{array}{r}2\\+2\\\hline\end{array}$

A-11 $\begin{array}{r}2\\+1\\\hline\end{array}$ $\begin{array}{r}3\\+1\\\hline\end{array}$

A-12 $\begin{array}{r}1\\+2\\\hline\end{array}$ $\begin{array}{r}1\\+3\\\hline\end{array}$

A-13 $\begin{array}{r}3\\+2\\\hline\end{array}$ $\begin{array}{r}4\\+2\\\hline\end{array}$

A-14 $\begin{array}{r}2\\+3\\\hline\end{array}$ $\begin{array}{r}2\\+4\\\hline\end{array}$

A-15 $\begin{array}{r}4\\+1\\\hline\end{array}$ $\begin{array}{r}5\\+1\\\hline\end{array}$

A-16 $\begin{array}{r}1\\+4\\\hline\end{array}$ $\begin{array}{r}1\\+5\\\hline\end{array}$

A-17 $\begin{array}{r}3\\+3\\\hline\end{array}$ $\begin{array}{r}3\\+4\\\hline\end{array}$

A-18 $\begin{array}{r}6\\+1\\\hline\end{array}$ $\begin{array}{r}7\\+1\\\hline\end{array}$

A-19 $\begin{array}{r}1\\+6\\\hline\end{array}$ $\begin{array}{r}1\\+7\\\hline\end{array}$

A-20 $\begin{array}{r}5\\+2\\\hline\end{array}$ $\begin{array}{r}6\\+2\\\hline\end{array}$

A-21 Review

A-22 $\begin{array}{r}2\\+5\\\hline\end{array}$ $\begin{array}{r}2\\+6\\\hline\end{array}$

A-23 $\begin{array}{r}4\\+3\\\hline\end{array}$ $\begin{array}{r}5\\+3\\\hline\end{array}$

A-24 $\begin{array}{r}3\\+4\\\hline\end{array}$ $\begin{array}{r}3\\+5\\\hline\end{array}$

A-25 $\begin{array}{r}6\\+3\\\hline\end{array}$ $\begin{array}{r}7\\+3\\\hline\end{array}$

A-26 $\begin{array}{r}3\\+6\\\hline\end{array}$ $\begin{array}{r}3\\+7\\\hline\end{array}$

A-27 $\begin{array}{r}5\\+4\\\hline\end{array}$ $\begin{array}{r}6\\+4\\\hline\end{array}$

A-28 $\begin{array}{r}4\\+5\\\hline\end{array}$ $\begin{array}{r}4\\+6\\\hline\end{array}$

A-29 $\begin{array}{r}7\\+2\\\hline\end{array}$ $\begin{array}{r}8\\+2\\\hline\end{array}$

A-30 $\begin{array}{r}2\\+7\\\hline\end{array}$ $\begin{array}{r}2\\+8\\\hline\end{array}$

A-31 $\begin{array}{r}8\\+1\\\hline\end{array}$ $\begin{array}{r}9\\+1\\\hline\end{array}$

A-32 $\begin{array}{r}1\\+8\\\hline\end{array}$ $\begin{array}{r}1\\+9\\\hline\end{array}$ $\begin{array}{r}5\\+5\\\hline\end{array}$

Unit VI - Simple Subtraction

A-33 $\begin{array}{r}2\\-1\\\hline\end{array}$ $\begin{array}{r}3\\-1\\\hline\end{array}$

A-34 $\begin{array}{r}3\\-2\\\hline\end{array}$ $\begin{array}{r}4\\-2\\\hline\end{array}$

A-35 $\begin{array}{r}4\\-1\\\hline\end{array}$ $\begin{array}{r}5\\-1\\\hline\end{array}$

A-36 $\begin{array}{r}6\\-1\\\hline\end{array}$ $\begin{array}{r}7\\-1\\\hline\end{array}$

A-37 $\begin{array}{r}5\\-2\\\hline\end{array}$ $\begin{array}{r}6\\-2\\\hline\end{array}$

A-38 $\begin{array}{r}4\\-3\\\hline\end{array}$ $\begin{array}{r}5\\-3\\\hline\end{array}$

A-39 $\begin{array}{r}6\\-3\\\hline\end{array}$ $\begin{array}{r}7\\-3\\\hline\end{array}$

A-40 $\begin{array}{r}7\\-2\\\hline\end{array}$ $\begin{array}{r}8\\-2\\\hline\end{array}$

A-41 $\begin{array}{r}8\\-1\\\hline\end{array}$ $\begin{array}{r}9\\-1\\\hline\end{array}$

A-42 $\begin{array}{r}7\\-4\\\hline\end{array}$ $\begin{array}{r}6\\-4\\\hline\end{array}$

A-43 $\begin{array}{r}6\\-5\\\hline\end{array}$ $\begin{array}{r}8\\-6\\\hline\end{array}$

A-44 $\begin{array}{r}7\\-5\\\hline\end{array}$ $\begin{array}{r}8\\-5\\\hline\end{array}$

A-45 $\begin{array}{r}9\\-5\\\hline\end{array}$ $\begin{array}{r}10\\-5\\\hline\end{array}$

A-46 $\begin{array}{r}7\\-6\\\hline\end{array}$ $\begin{array}{r}9\\-6\\\hline\end{array}$

A-47 $\begin{array}{r}5\\-4\\\hline\end{array}$ $\begin{array}{r}9\\-3\\\hline\end{array}$

A-48 $\begin{array}{r}8\\-7\\\hline\end{array}$ $\begin{array}{r}9\\-7\\\hline\end{array}$

A-49 $\begin{array}{r}9\\-8\\\hline\end{array}$ $\begin{array}{r}10\\-8\\\hline\end{array}$

A-50 $\begin{array}{r}9\\-2\\\hline\end{array}$ $\begin{array}{r}9\\-4\\\hline\end{array}$

A-51 $\begin{array}{r}8\\-3\\\hline\end{array}$ $\begin{array}{r}8\\-4\\\hline\end{array}$

A-52 $\begin{array}{r}10\\-3\\\hline\end{array}$ $\begin{array}{r}10\\-4\\\hline\end{array}$

A-53 $\begin{array}{r}10\\-2\\\hline\end{array}$ $\begin{array}{r}10\\-1\\\hline\end{array}$

A-54 $\begin{array}{r}10\\-6\\\hline\end{array}$ $\begin{array}{r}10\\-7\\\hline\end{array}$ $\begin{array}{r}10\\-9\\\hline\end{array}$

Unit VII - Concept of Zero

A-55 Recognition of zero
A-56 Zero in the number sequence
A-57 Rational counting with zero

A-58 $\begin{array}{r}1\\+0\\\hline\end{array}$ $\begin{array}{r}2\\+0\\\hline\end{array}$

A-59 $\begin{array}{r}0\\+1\\\hline\end{array}$ $\begin{array}{r}0\\+2\\\hline\end{array}$

A-60 $\begin{array}{r}3\\+0\\\hline\end{array}$ $\begin{array}{r}4\\+0\\\hline\end{array}$

A-61 $\begin{array}{r}0\\+3\\\hline\end{array}$ $\begin{array}{r}0\\+4\\\hline\end{array}$

A-62 $\begin{array}{r}5\\+0\\\hline\end{array}$ $\begin{array}{r}6\\+0\\\hline\end{array}$

A-63 $\begin{array}{r}0\\+5\\\hline\end{array}$ $\begin{array}{r}0\\+6\\\hline\end{array}$

A-67 $\begin{array}{r}0\\+9\\\hline\end{array}$ $\begin{array}{r}0\\+10\\\hline\end{array}$

A-68 $\begin{array}{r}0\\+0\\\hline\end{array}$

A-72 $\begin{array}{r}7\\-0\\\hline\end{array}$ $\begin{array}{r}8\\-0\\\hline\end{array}$

A-73 $\begin{array}{r}9\\-0\\\hline\end{array}$ $\begin{array}{r}10\\-0\\\hline\end{array}$

A-64 7 8 A-69 1 2 A-74 0
+0 +0 -0 -0 -0

A-65 0 0 A-70 3 4 A-75 1
+7 +8 -0 -0 -1

A-66 9 10 A-71 5 6 A-76 2
+0 +0 -0 -0 -2

A-77 3 A-78 4 A-79 5 A-80 6
-3 -4 -5 -6

A-81 8 9 10
-8 -9 -10

Unit VIII - Number recognition and rote counting 11-50

A-82 Number recognition 11 thru 13
A-83 Number recognition 14 thru 16
A-84 Number recognition 17 thru 20
A-85 Number sequence 11 thru 15
A-85a Number sequence 16 thru 20
A-86 Number recognition 21 thru 23
A-87 Number recognition 24 thru 26
A-88 Number recognition 27 thru 30
A-89 Number sequence 21 thru 25
A-89a Number sequence 26 thru 30
A-90 Number recognition 31 thru 34
A-91 Number recognition 35 thru 37
A-92 Number recognition 38 thru 40
A-93 Number sequence 31 thru 35
A-93 Number sequence 36 thru 40
A-94 Number recognition 41 thru 44
A-95 Number recognition 45 thru 47
A-96 Number recognition 48 thru 50
A-97 Number sequence 41 thru 44
A-97a Number sequence 45 thru 47
A-98 Review number sequence 1 thru 50
A-99 Review number sequence 1 thru 50
A-100 Review number sequence 1 thru 50

Unit IX - Readiness for Multiplication and Division

A-101 Recognition of words yes and no
A-102 Developing 1, 2 and 3 groups of 2 objects
A-103 Developing 4, 5 and 6 groups of 2 objects
A-104 Developing 7, 8 and 9 groups of 2 objects
A-105 Equal and unequal groups of 2 objects

A-106 Developing 1, 2 and 3 groups of 3 objects
A-107 Developing 4, 5 and 6 groups of 3 objects
A-108 Developing 7, 8 and 9 groups of 3 objects
A-109 Equal and unequal groups of 3 objects
A-110 Developing 1, 2 and 3 groups of 4 objects
A-111 Developing 4, 5 and 6 groups of 4 objects
A-112 Developing 7, 8 and 9 groups of 4 objects
A-113 Equal and unequal groups of 4 objects
A-114 Developing 1, 2 and 3 groups of 5 objects
A-115 Developing 4, 5 and 6 groups of 5 objects
A-116 Developing 7, 8 and 9 groups of 5 objects
A-117 Equal and unequal groups of 5 objects
A-118 Column addition - 2's and 3's
A-119 Column addition - 4's and 5's
A-120 Counting by 2's thru 10
A-121 Counting by 2's thru 20
A-122 Recognition of Multiplication sign

Unit X - Multiplication by 2's

A-123 $\begin{array}{r} 2 \\ \text{x}3 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}2 \\ \hline \end{array}$

A-123a $\begin{array}{r} 2 \\ \text{x}1 \\ \hline \end{array}$

A-123b $\begin{array}{r} 3 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 1 \\ \text{x}2 \\ \hline \end{array}$

A-124 $\begin{array}{r} 2 \\ \text{x}4 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}5 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}6 \\ \hline \end{array}$

A-124a $\begin{array}{r} 4 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 5 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 6 \\ \text{x}2 \\ \hline \end{array}$

A-125 $\begin{array}{r} 2 \\ \text{x}7 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}8 \\ \hline \end{array}$ $\begin{array}{r} 2 \\ \text{x}9 \\ \hline \end{array}$

A-125a $\begin{array}{r} 7 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 8 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 9 \\ \text{x}2 \\ \hline \end{array}$

Unit XI - Readiness for Division

A-126 Recognition of Division sign
A-127 Review concept of equality and introduce concept of dividing large groups into smaller equal groups

Unit XII - Partitive Division by 2's

A-128 $2\overline{)2}$ $2\overline{)4}$ $2\overline{)6}$

A-129 $2\overline{)8}$ $2\overline{)10}$ $2\overline{)12}$

A-130 $2\overline{)14}$ $2\overline{)16}$ $2\overline{)18}$

Unit XIII - Multiplication and Partitive Division with 3's and 4's

A-131 $\begin{array}{r}1\\ \underline{x3}\end{array}$ $\begin{array}{r}2\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x1}\end{array}$ $\begin{array}{r}3\\ \underline{x2}\end{array}$

A-132 $1\overline{)3}$ $3\overline{)3}$

A-132a $3\overline{)6}$ $2\overline{)6}$

A-133 $\begin{array}{r}3\\ \underline{x3}\end{array}$ $\begin{array}{r}4\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x4}\end{array}$

A-134 $3\overline{)9}$ $3\overline{)12}$ $4\overline{)12}$

A-135 $\begin{array}{r}5\\ \underline{x3}\end{array}$ $\begin{array}{r}6\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x5}\end{array}$ $\begin{array}{r}3\\ \underline{x6}\end{array}$

A-136 $3\overline{)15}$ $5\overline{)15}$

A-136a $3\overline{)18}$ $6\overline{)18}$

A-137 $\begin{array}{r}7\\ \underline{x3}\end{array}$ $\begin{array}{r}8\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x7}\end{array}$ $\begin{array}{r}3\\ \underline{x8}\end{array}$

A-138 $3\overline{)21}$ $7\overline{)21}$

A-138a $3\overline{)24}$ $8\overline{)24}$

A-139 $\begin{array}{r}9\\ \underline{x3}\end{array}$ $\begin{array}{r}3\\ \underline{x9}\end{array}$

A-139a Review

A-140 3 27 9 27

A-140a Review

A-141 $\begin{array}{r}1\\ \underline{x4}\end{array}$ $\begin{array}{r}2\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x1}\end{array}$ $\begin{array}{r}4\\ \underline{x2}\end{array}$

A-142 $1\overline{)4}$ $4\overline{)4}$

A-142a $2\overline{)8}$ $4\overline{)8}$

A-143 $\begin{array}{r}3\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x3}\end{array}$ $\begin{array}{r}4\\ \underline{x4}\end{array}$

A-144 $3\overline{)12}$ $4\overline{)12}$ $4\overline{)16}$

A-145 $\begin{array}{r}5\\ \underline{x4}\end{array}$ $\begin{array}{r}6\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x5}\end{array}$ $\begin{array}{r}4\\ \underline{x6}\end{array}$

A-146 $4\overline{)20}$ $5\overline{)20}$

A-146a $4\overline{)24}$ $6\overline{)24}$

A-147 $\begin{array}{r}7\\ \underline{x4}\end{array}$ $\begin{array}{r}8\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x8}\end{array}$ $\begin{array}{r}4\\ \underline{x7}\end{array}$

A-148 $4\overline{)28}$ $7\overline{)28}$

A-148a $4\overline{)32}$ $8\overline{)32}$

A-149 $\begin{array}{r}9\\ \underline{x4}\end{array}$ $\begin{array}{r}4\\ \underline{x9}\end{array}$ Review

A-150 $4\overline{)36}$ $9\overline{)36}$

A-150a Review

Unit XIV - Multiplication and Partitive Division with 5's

A-151 Counting by 5's thru 25

A-152 Counting by 5's thru 50

A-153 $\begin{array}{r}5\\ \underline{x2}\end{array}$ $\begin{array}{r}5\\ \underline{x1}\end{array}$

A-153a $\begin{array}{r}2\\ \underline{x5}\end{array}$ $\begin{array}{r}1\\ \underline{x5}\end{array}$

A-154 $1\overline{)5}$ $2\overline{)10}$

A-154a $5\overline{)5}$ $5\overline{)10}$

A-156a $4\overline{)20}$ $5\overline{)20}$

A-157 $\begin{array}{r}5\\ \underline{x5}\end{array}$ $\begin{array}{r}5\\ \underline{x6}\end{array}$

A-157a $\begin{array}{r}5\\ \underline{x5}\end{array}$ $\begin{array}{r}6\\ \underline{x5}\end{array}$

A-157b $5\overline{)25}$ $5\overline{)30}$ $6\overline{)30}$

A-158 $\begin{array}{r}5\\ \underline{x7}\end{array}$ $\begin{array}{r}5\\ \underline{x8}\end{array}$

A-155	$\begin{array}{r}5\\ x3\\ \hline\end{array}$	$\begin{array}{r}5\\ x4\\ \hline\end{array}$		
A-155a	$\begin{array}{r}3\\ x5\\ \hline\end{array}$	$\begin{array}{r}4\\ x5\\ \hline\end{array}$		
A-156	$3\overline{)15}$	$5\overline{)15}$		
A-158a	$\begin{array}{r}7\\ x5\\ \hline\end{array}$	$\begin{array}{r}8\\ x5\\ \hline\end{array}$		
A-159	$5\overline{)35}$	$7\overline{)35}$	$5\overline{)40}$	$8\overline{)40}$
A-160	$\begin{array}{r}5\\ x9\\ \hline\end{array}$	$\begin{array}{r}9\\ x5\\ \hline\end{array}$	Review	
A-160a	$5\overline{)45}$	$9\overline{)45}$		

Unit XV - Review of Four Basic Processes

A-161 Review of four signs
A-162 Experience with four processes independent of algorisms-groups of four objects
A-163 Same as above - groups of six objects
A-164 Experience with algorisms

	$\begin{array}{r}2\\ +2\\ \hline\end{array}$	$\begin{array}{r}4\\ -2\\ \hline\end{array}$	$\begin{array}{r}2\\ x2\\ \hline\end{array}$	$2\overline{)4}$
A-165	$\begin{array}{r}3\\ +3\\ \hline\end{array}$	$\begin{array}{r}6\\ -3\\ \hline\end{array}$	$\begin{array}{r}3\\ x2\\ \hline\end{array}$	$2\overline{)6}$
A-166	$\begin{array}{r}4\\ +4\\ \hline\end{array}$	$\begin{array}{r}8\\ -4\\ \hline\end{array}$	$\begin{array}{r}4\\ x2\\ \hline\end{array}$	$2\overline{)8}$
A-167	$\begin{array}{r}5\\ +5\\ \hline\end{array}$	$\begin{array}{r}10\\ -5\\ \hline\end{array}$	$\begin{array}{r}5\\ x2\\ \hline\end{array}$	$2\overline{)10}$
A-168	$\begin{array}{r}6\\ +6\\ \hline\end{array}$	$\begin{array}{r}12\\ -6\\ \hline\end{array}$	$\begin{array}{r}6\\ x2\\ \hline\end{array}$	$2\overline{)12}$
A-169	$\begin{array}{r}7\\ +7\\ \hline\end{array}$	$\begin{array}{r}14\\ -7\\ \hline\end{array}$	$\begin{array}{r}7\\ x2\\ \hline\end{array}$	$2\overline{)14}$
A-170	$\begin{array}{r}8\\ +8\\ \hline\end{array}$	$\begin{array}{r}16\\ -8\\ \hline\end{array}$	$\begin{array}{r}8\\ x2\\ \hline\end{array}$	$2\overline{)16}$
A-171	$\begin{array}{r}9\\ +9\\ \hline\end{array}$	$\begin{array}{r}18\\ -9\\ \hline\end{array}$	$\begin{array}{r}9\\ x2\\ \hline\end{array}$	$2\overline{)18}$

Unit XVI - Fractions

A-172 Concept of 1/2 as part of a whole
A-172a Recognition of 1/2 as a numerical fraction
A-173 Concept of 1/4 as part of a whole
A-173a Recognition of 1/4 as a numerical fraction
A-174 Concept of 1/3 as part of a whole
A-174a Recognition of 1/3 as a numerical fraction
A-175 Comparison of 1/2, 1/4 and 1/3

Appendix D

Behavior Rating Basal Scale*

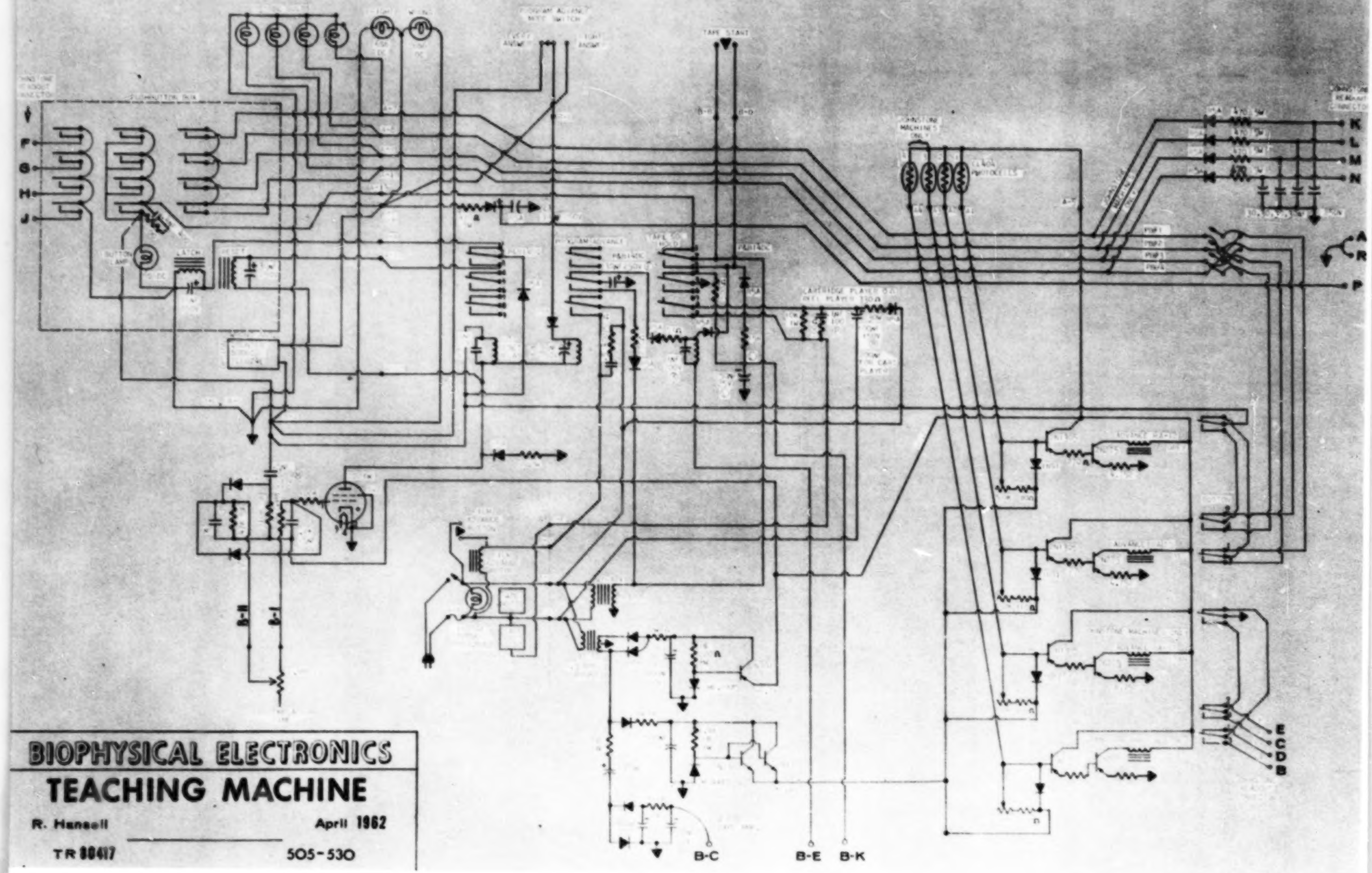
1. Conformity to requests - general cooperativeness.
2. Individual constructive activities.
3. Participation with the group.
4. Interaction with individuals.
5. Interest and progress in learning.
6. Independence and self-help.
7. Persistence with tasks.
8. Constructive conversation and communication.
9. Excessive conversation.
10. Stability of activity level - degree of freedom from hyperactivity.
11. Absence of anti-social behavior and fighting.
12. Absence of irritability.
13. Ability to tolerate frustration.
14. Apparent health.

*Scales are presented by titles only. For copies of the full BRBS with instructions contact Dr. Harriet Blodgett, Director, Sheltering Arms, River Road, Minneapolis, Minnesota.

Revised Behavior Rating Basal Scale*

1. Conformity to requests - general cooperativeness.
2. Individual constructive activities.
3. Participation with the group.
4. Interaction with individuals.
5. Interest and progress in learning.
6. Independence and self-help.
7. Persistence with tasks.
8. Conversation and Communication.
9. Stability of activity level.
10. Absence of anti-social behavior and fighting.
11. Absence of irritability.
12. Ability to tolerate frustration.

*Scales are presented by titles only. For copies of the full BRBS with instructions contact Dr. Harriet Blodgett, Director, Sheltering Arms, River Road, Minneapolis, Minnesota.


F
G
H
J
PUSHBUTTON BOX
BUTTON LAMP
LATCH
RESET
PROGRAM ADVANCE
TAPE START
B-D
CARTRIDGE PLAYER
JOHNSTONE MACHINES ONLY
PHOTOCELLS
K
L
M
N
A
R
P
E
C
D
B
B-II
B-I
B-C
B-E
B-K

BIOPHYSICAL ELECTRONICS

TEACHING MACHINE

R. Hansell April 1962

TR 80417 505-530